

AUTOMATIC VERSUS AUTOMATIC,
MATERIALIZED FICTION AS A
CONFRONTATIONAL COMPOSITIONAL
PROCESS

A resolved complexity: simplicity

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cartoon by I. Riutin, from *The Search for the Truth*, by A. B. Migdal

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Abstract

The current submitted work consists of a portfolio of musical works, visual pieces and thoughts that preoccupied me over a period of research and creation from late 2014 to 2017. Pieces described in this thesis developed into an overall artistic research and craft which led to a specific workflow serving a new personal aesthetic. Two parts describe two seemingly antonymous automatic creation processes: automatic versus automatic.

The first part describes my inspirations together with a consequent formalization of my composition techniques. I render generative automatic music both emerging from finite state computation and infinitesimal interference.

The second part shows that I often perform my music in specific sites with challenging conditions. I consider them as constraints that eventually also become part of the composition system. The materialization of a piece involves a back-and-forth process, between concepts and realities, that I finally transcend in the sense of surrealist automatism. This mechanical and human process is a necessity for the authenticity to my pieces.

Keywords: *composition, electronic music, computational design, material, concept, generative, artificial creativity, spatial computing.*

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Introduction

The current work consists of a portfolio of musical works, visual pieces, and text which should be considered as one single work required for the degree of Doctor of Philosophy. Pieces described in this thesis have been premiered or experimented during the three and a half years.¹ They inhere within the natural continuation of my previous audio, visual and textual works. But in these pieces, thoughts and inspirations also resulted in decisive and definite artistic consequences. They developed into an overall artistic research and craft which led to a specific workflow serving a new personal aesthetic and a precise musical context.

The two parts of the thesis both describe two seemingly antonymous automatic creation processes. The first one describes the automatization of self-operating automaton. A simple generative composition emerges from computation and interference. I define the concept that inspires me and best fits my goals for an infinitesimal and meticulous piece. The second part reveals that my personal conceptualization is always a theory-fiction that can sometimes be a narrative. It sometimes links with the dramaturgy of specific pieces. Perceived complexity, fabrication, and materialization bring constraints barely avoided in the real world; time, space, social aspect. . . . Transcendence of the process is the desired outcome of an eternal feedback between conceptualization and practice. It underlines again the question of automatic composition as an act of creation.

As fascinating and autonomous as these compositions can be, my personality and culture nevertheless forced me to maintain some sort of control. This approach is rather new for me and I would like to believe it will eventually become fully automatic. This naive, but fascinating quest ignores necessary satisfaction needed for a work to become a piece. The main interest of a piece would then take the form of social situations, providing transcendence that only humans can interestingly provide to other humans. Questions of ultimate control and preeminence are consequences. To me, irrationality is imperative and determines an art piece.

¹In relation with experimentation.

Chapter 1

Systems composition

1.1 Introduction

The following part describes the systematic approach of my compositions, my attempts at formalism which are usually transcended later in the composition process, as we will see in chapter 3. In general, my works are both audio and visual: each one is an incarnation of one single concept, but not conceived as multimedia.

We will first see, in 1.2.1, that the audio and visual components are very related, but in a disassociated way; this is a method for me, as a composer, to be inspired by two renderings of a single idea. We will then see, in 1.2.2, that the public is invited to read, explore, and freely interpret each layer of pattern and media in parallel, without this process being essential to understand each self-contained media component. We will finally see that this inter-relation can be considered as an optional abstract listening score for the electronic music (1.2.3). This score has no time-line per say; multiple perspectives on time are parameters like any others.

The second part, 1.3.2, describes how those complex layers are fused in a succession of continuous relations between states. I will explain how I use spatial computation as a powerful tool for such processes, and what kind of approach I chose to take.

Finally, the last part, 1.4, shows how these complex layers are both waves and particles depending on the scale at which we consider them. We will first see how scales are related to each other, and will finally see how a musical textures emerges from infinitesimal coexisting scales and defines a piece.

I will therefore begin by describing how I personally conceive composition. Visual and audio aspects are both in parallel and initially emerge from the same single concept. We will see I often start from graphic rendering which is later applied to audio. Such geometric and linear algebraic approaches lead to composition using interconnected curves of parameters, and their mapping will be critically discussed, with the goal of letting the music emerge from their cohabiting complexity.

1.2 Audio-visuals and electronic music scores

I will describe here consecutive relations I construct between visual and sound composition. I do not create strict synesthesia, but rather consider pieces as scores offered to be read by an audience with both their ears and eyes.

1.2.1 Dissociated audio-visuals

We will later see in this thesis (2.3) that I consider not only purely sonic parameters but also spatial and social ones. It is a larger desire, reminiscent consideration of the total experience like Wagner with his *Gesamtkunstwerk*. This total art can conceive the art piece from the core of its creative process. On the other hand, I do not consider my work multimedia, but rather a set of parallel renderings using various media. The coexistence and inter-relation of several renderings makes one single piece. Coming from the same concept, both are sometimes not related at all and only connected by the listener himself. In the next section I will discuss the different associations that can be made at the level of compositional material with the listener and through my composition process; I will discuss the clashes it creates with the romantic ideal in 2.3.1.

Romantic quest for a dramatic *Gesamtkunstwerk*



fig. 1.1 - *Tristan and Isolde* in the first performance in 1865.

I have a special interest in Romanticism. This XVIIIth century movement partly comes from a reaction to the Industrial Revolution, a new era of enlightenment, and a scientific rationalization. This still impacts my work from its emphasis on emotion and moreover its glorification of Nature. But I personally see its transposition into a more contemporary culture; I tend to substitute the true glorified Nature by artificial simulations. Copying Nature was in fact already the case by then, but the idea of a live-full simulation is only possible nowadays.

The way I therefore perceive the work of Richard Wagner is rather particular. I enjoy the aesthetics strongly attached to his time. For instance, in certain climaxes, he made the violins move in an intricate network of figuration around blaring brasses that he did not hesitate to use in unison. For me, the way he used such tension is the dominant factor governing the form of the entire piece itself. This dominant aesthetic controls the entirety of his pieces, giving an impressive sense of greatness. That dramatic aspect became a cliché used in the cinema industry of the XXth and XXIst centuries.

Richard Wagner describes his idea of *Gesamtkunstwerk* after 1849 in *Art and Revolution* (Wagner, 1849):

“Each one of these dissevered arts, nursed and luxuriously tended for the entertainment of the rich, has filled the world to overflowing with its products; in each, great minds have brought forth marvels; but the one true Art has not been born again, either in or since the Renaissance. The perfect Art-work, the great united utterance of a free and lovely public life, the Drama, Tragedy, howsoever great the poets who have here and there indited tragedies, is not yet born again: for reason that it cannot be re-born, but must be born anew.”

Richard Wagner, *Art and Revolution* (Wagner, 1849).

The notion of total, and perfect, art conceptually unifies music, song, dance, poetry, visual arts and stagecraft into a single romantic art piece subsidiary to drama. Besides some very polemical articles, he characterizes his conception of music-drama as the quest for the ultimate plot to integrate music together with other elements of a piece; especially dramaturgy. He simply means music should be part of a whole narrative. Its interpretation has therefore to be as close as possible to its score. He elaborates his operas by juxtaposing simultaneous perceptions where each element springs from a distinct development. Such a work of art is to be the clearest and most profound expression of a folk legend, though abstracted from its nationalist particulars to a universal humanist fable. Richard Wagner and other romantic and post-romantic composers comprehend their own notion of synesthesia within their own lifetime; their musical work is framed or integrated with other media and is considered as only one element of a wider composition.¹ The complexity or richness of the pieces goes beyond their merely sonic part. I personally consider the structural complexity has a true aesthetic value when associated with a social and physical context; and this is what these composers tried to achieve.

¹Gustav Mahler and Igor Stravinsky also involved themselves into this quest but I prefer Richard Wagner for his monumental and symbolic aspects.

We will see that I also often associate my work with a more humble compositional quest for control and unification (1.3.3, 2.3.1). The meaning is very different from Richard Wagner's political views (Strong, 1998). Indeed, I perceive his concept from a more contemporary and humanist perspective. The synergy is similar but the rise of abstract art and multimedia techniques lead me to a different path. Drama lies within a more internal concept, for convenience described by an algorithm. All the elements of a piece are part of a global concept and are not separated as they would be in multimedia pieces. They are only later presented by multimedia and multi-nodal materialized representations.

Physical and conceptual parallel of patterns

The existence of a piece lies beyond the limits of one performance. We can then talk about dissociated audio-visual in which various senses or elements are given notions of memory and prescience allowing comparison. The juxtapositions of media are not only considered vertically within the timescale of one presentation. They lie in many dimensions defining the space of the piece in a complex system of interrelated elements. For instance, the hall and the acoustic where the opera is performed are critical. The way the audience is prepared, and the order in which pieces are presented in a concert are also important to me.

In dance, Christian Rizzo, or William Forsythe, sometimes use elements apposed together. They both pair gestures with historical pictures that can be recognized from the audience's knowledge. They mix elements from the actual dance with others that are outside of the show itself. Also, Ryoji Ikeda's or Frank Bretschneider's minimalistic patterns come from the simplest possible signal processing sources. These simplistic patterns are symbols that become physical enough for the audience to recognize and follow; perception at its lowest level is their outer complexity.

Various representations before (score, plan), during (score, video) and after (remembering, critics) the presentation should then be taken into account within the concept. The ultimate piece is the construction of an entire, fully understood and controlled universe. But in any case, the piece will always eventually exist by itself; independently from the composer's control, freely. It is then up to the audience to seize it and build parallels of coexisting patterns from both its perception and subjective background (2.2).

Kaspar: a key piece rendered to multiple media and offered for several interpretations

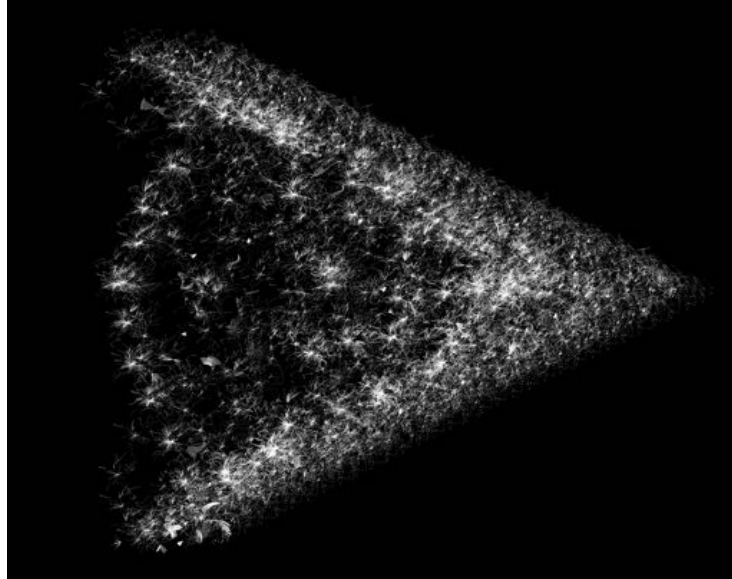


fig. 1.2 - One print of *Kaspar I*. The print is two meters wide.

In 2010, I composed a piece that I consider as being a milestone in my research. It gives a valuable context for the pieces described in this document. That piece is also influenced by another important and even older one called *Machinations*. *Kaspar* was commissioned by the June in Buffalo 2010 festival.

“Peter Handke’s play Kaspar is an example neither of theater of the Absurd nor Anti-theater. It does not follow traditional concepts of conventional drama, since it is neither representational nor descriptive. Absent as well are plot, characters, tension, coherence, connecting processes, and meanings of words as we understand them. A spectator, therefore, must not compare stage reality with the reality he or she knows. Events represent themselves-no more, no less.”

Bettina Knapp, *Peter Handke’s Kaspar: The Mechanics of Language —
A Fractionating Schizophrenic Theatrical Event* (Knapp, 1990).

Kaspar is a play by Peter Handke written in 1967 (Hanke, 1967). Handke’s *sprechstücke*, through focusing on the performance of language, partake in the postmodern critique of representation. As a species of “non-matrixed” theater;

a theater which avoids the strong traditional fictional matrices of time, place, character, situation, and action, the “speech-plays” raise interesting issues pertaining to language, representation, presence, and performance. This is perfect for a piece about presentation, representation and materialization.



fig. 1.3 - Another print of *Kaspar I* displayed in one dimension.

The piece is made of super high resolution (dpi) prints on paper (not actively sending light as a screen would do) and tiny sounds projected into the exhibition space (fig. 1.2 & 1.3). Both the audio and visual parts consist of tiny rhythmic patterns composed of millions of microscopic dots one can barely perceive. Their spacing has an emphasis from both close and far away. The picture shown in fig. 1.3 has only one dimension and allows visitors to comprehend relative placements of dots. These positions result from perspective effects and projection. Density of aligned dots varies according to the angle of projection. The higher the angle is, the closer will be the dots that will eventually make continuous lines. The haftoning effect and its consequent variety of grey levels are more clearly visible in two dimensions (fig. 1.3).

These patterns have previously been generated in three dimensions. Each pattern is placed in the space according to an Ulam spiral and following aggregation assembly technique.² One of the many artistic choices happens at the moment of reduction of dimensions. This is a subjective projection: a point of view.

Kaspar has no real technical link with Peter Handke’s play. The existence of a practical link between the generated form and the audio-visual result is no obligation. That connection can freely be anything else, such as physical, esoteric or simply non existent (2.3.2). Clever connections between entities and media indeed depend on pure interpretation and subjective choices.

Kaspar has an obvious geometric approach because its projections and re-

²I found out aggregation and percolation very intuitive processes (1.2.3). A Ulam spiral is a way of organizing set of prime numbers in a spiral.

sulting curves, planes and spaces are the result of form processes. For instance, all coordinates, all ratios change from one simple rotation. But some logic and direct connection are still kept for the rotated object (1.3.2).

The sounds of *Kaspar* consist of very high pitched rhythmic patterns, thus giving a sense of precision. This also brings a touch of minimalism, rather important for such a perceptual complex piece. There is a relation to chamber music, in which the public is invited to actively listen to quiet and subtle sonic elements. The audience is visually and sonically deciphering similarities in a similar way to how it would read a text onto paper, or e-paper. The notion of score here is thus very important.

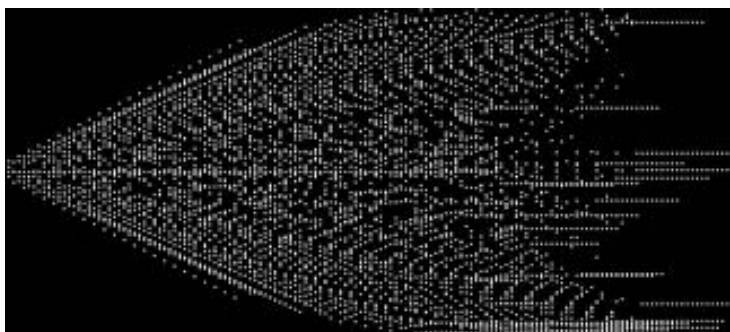


fig. 1.4 - Projection of a large three dimensional Ulam spiral into two dimensions for *Kaspar I*. The angle of projection is an artistic choice. Each dot will later hook the aggregation of a rhythmic tree structure.

1.2.2 Reading, exploring and interpreting

Energetic lines as an associative complex system

In an interview on *Die Reihe*, Luciano Berio remarks that the study of counterpoint is the best way to associate the ear with the pen (Stockhausen et al., 1955). This way, he outlines the importance of the time relationship between hearing and gesture. The act of writing is a materialization.³ With a more general approach, counterpoint presupposes, or supposes, a correlation between elements. I am not only referring to traditional musical counterpoint elaborating the relationship between the voices that are harmonically interdependent and independent in rhythm and contour. I am more invoking interconnections between all kinds of composition parameters and elements over time, or any other chosen fixed dimension. This complex game of association and dissociation between varying parts gives real interest to a piece of music. This defines what music is to me, and its consequences should be visible in my work (fig. 1.5).

³The term *fabrication* is used in architecture and rather fits with the idea of Materialization.

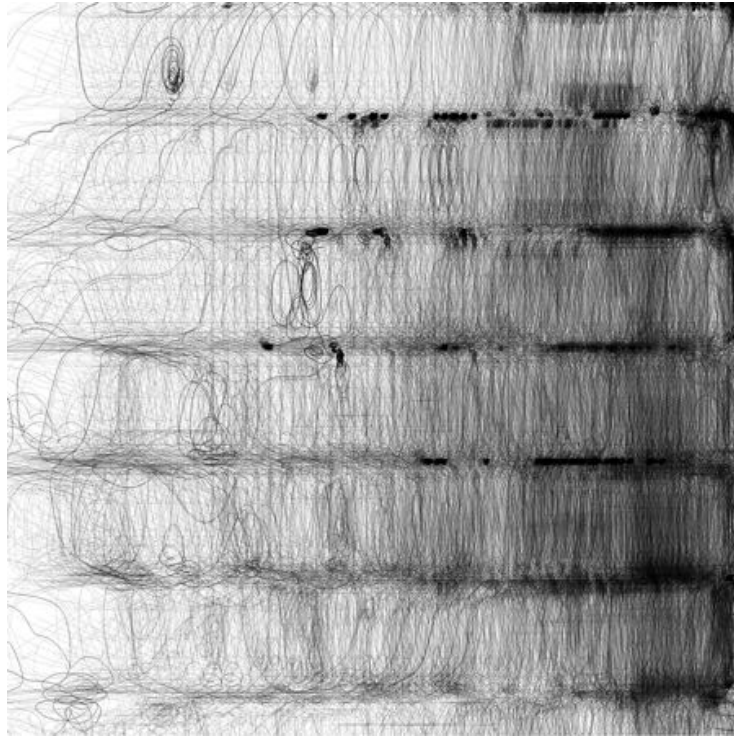
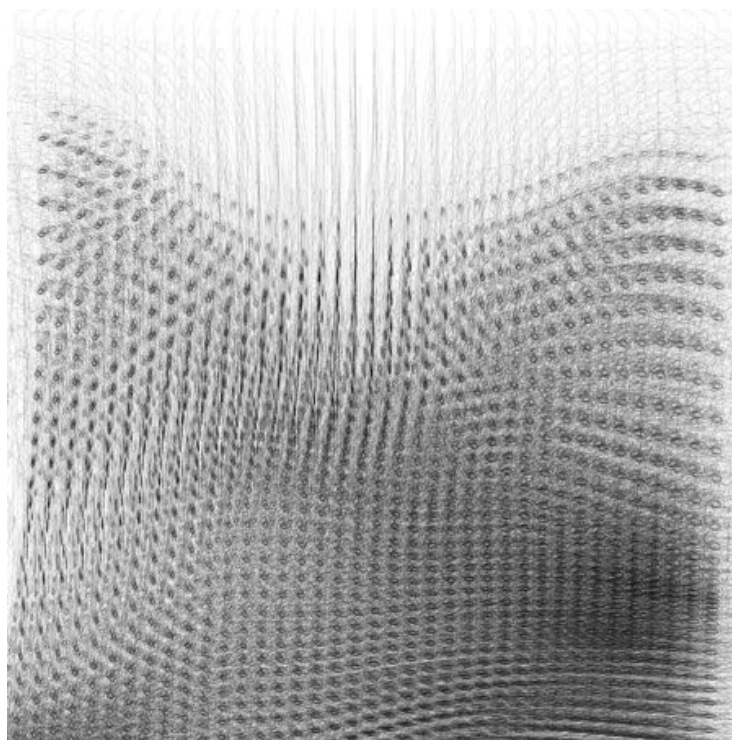


fig. 1.5 - Print of *d[score]*, 2016, invites the viewer to associate loops with weaving.

Luciano Berio's saying in my opinion also exposes the importance of the writing as a trace, and as a gesture. It allows the projection from one medium to another and gets rid of real-time using readable symbolic representations of signal: notation. Positions either in space or time are then a complex system whose associations are to be explored. Conceptual associations are understood as energetic lines of concentration. The counterpoint described here is the parallelism between these complementary lines. The analysis of associations is to be made by the reader or listener. This defines the initial characteristic and an aspect I have chosen for my music.

Progression, and transformation of states as composition engine

In the previous part, I have described the character and aspect on which I am willing to concentrate on my music. This static explanation nevertheless needs to be given a movement to exist. This movement needs a listener rather than a time. In fact, it needs the listener's time, given out of a personal motivation.

fig. 1.6 - Another print of $d[score]$.

The motivation may come from the curiosity to explore thoughts, feelings and sensations given by evolution. I see this engine as a *thought experiment* for the reader or listener. The latter internally thinks of consequences one could expect from given information and situation.⁴ Because it is an artistic experiment, un-deterministic consequences are expected to emerge from reasoning (2.2.1). There is an intellectual deliberation in order to speculate about what has happened and what will happen, or not happen. But it is no scientific experiment, so reasoning does not have to be Cartesian and linked with any truth or belief; it is a fictional concept (1.2.1). The structure of the experiment, may not be possible to be materialized; I here place everything from the listener's point of view. Experiment leads to experience when its mechanism makes the listener react to it; it is for me the feedback of a thought experience.

We will see later that the patterns explored in my pieces are pre-defined elements coming from some kind of segmentation of the information. The definition can sometimes come from a cultural background. But while still coming from the listener, it mostly comes after the first analysis of the piece and is subject to change over time. The associations of these elements described earlier

⁴I maybe see a link here with the situationists, where the spectacle's focus is central and beyond the frame of the performance itself.

are experienced together with the elements themselves (1.2.2). The evolution of such units makes the piece musical. For instance, pitches often lose their musical value if they are not contextualised with one another. Composers use probabilities of transitions rather discrete states. It is then a question of genetics: the evolution of initial states from one to another in a given context. Static states are also important because they are the architecture, the skeleton of the system (1.4.2).

The overall piece is the emergence of complicated nested weaving (1.4.3). I therefore would not define my music as being the art of time. It is from my point of view rather the art of states and their evolution emerging from a previously defined formalization.

Motion as a need for materialization and interpretation

Motion is the strongest visual call to attention. A dog may be resting peacefully, unimpressed by all the lights and shapes that make up the immobile setting around him; but as soon as anything moves, his eyes will turn to the spot and follow the course of the motion (Arnheim, 1974). Similarly Stanislas Dehaene has developed computational models showing that consciousness comes from diverse “latencies” between parts of the brain (Dehaene, 2014).⁵ It is an internal motion between elements consequently involving time and space. There could perhaps be an analogy with a mechanical clock pendulum using gravitation for measuring the distance between events.⁶ True or not, this view is one of many ways to conceptually link time and space using the motion of elements or motion within these elements. That implies a difference, or more often a ratio, of one object between states; a change (Anderson, 1972). Materialization is a fabrication that changes matter, it moves it; before moving the listener.

⁵Using magnetic resonance imaging which not so surprisingly resembles some of my work.

⁶Gravitation probably has strong links with the existence of time in physics (Klein, 2004).

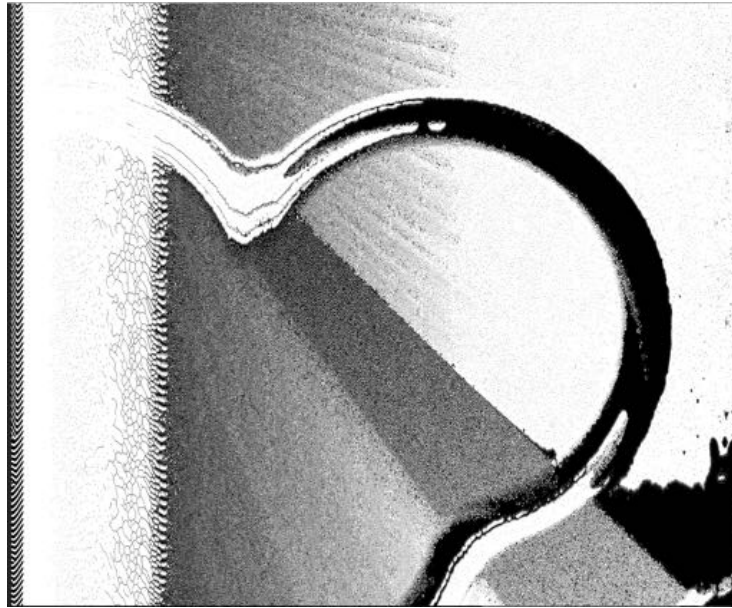


fig. 1.7 - Snapshot of the video *Proxima b1*, 2017. Real-time is made by the succession of displacement iterations in the process. Simplicity here creates a complexity from the amount of iterations, thus rendering an artificial nature; a kind of minimalism (1.4).

Representation of a space-time concept

We have noticed that I want to conceptualize my music and somehow make it descriptive enough to truly be generative and autonomous. The concept is the central aspect of the piece.⁷ It permits listeners to concentrate on content beyond sound itself which is here considered as a vector, or at least a representation. I sometimes apprehend piano music purely conceptually, because I concentrate on the form and the intellectual sensation it provides. Actual timbres are primary, but they are transcended by the music as architecture. Ben Johnston's microtonal piano music, or James Tenney's *Spectral Canon for Conlon Nancarrow*, nevertheless merges notes with timbre together with the musical content itself. Composition parameters are tightly connected to each other that they make the whole piece as a singular musical object.

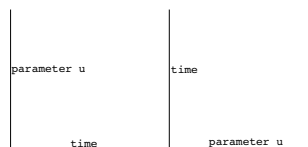


fig. 1.8 - The question of bijection and coordinate swapping for time. The Simpson paradox and its confusion factors do not matter since I subjectively decide the curves.

⁷There is no obligation for this concept to be of any sort of reasoning (2.3).

I therefore need to be able to consider, and represent, time as if it were any other parameter; just another dimension. This allows me to have as many times as I want; the real-time, the one from the listener, the ones from machines, from the concept and so on. It also allows me to swap parameters while keeping the same functions, and to subjectively decide on a mapping from projections (fig. 1.8) (Giavitto et al., 2015).⁸ There is no time, no space at that point of the composition process.

In *Confessions*, Augustine of Hippo tries to define time as something being lived, experienced (d’Hippone, 400). For him, time is purely internal. Past corresponds to memory, present is current attention and future is expectation. This is the motivation for expectation described earlier (1.2.2). Blaise Pascal’s *Pensées* goes one step further. It describes time in a more psychological and less pious way. His physiologic conception allows quantification and consequently the possibility of allowing an evolution of time over time (Pascal, 1660).

Isaac Newton sees time as a flow; a continuity. Albert Einstein is somehow closer to Blaise Pascal; he sees time as a variable function of matter and energy.⁹ Iannis Xenakis’s *Metastaseis* is a very good use of interleaved energy constrained functions (Xenakis, 1992). The metaphor of a cannon barrel describes pretty well the idea of energy and boundaries:

“Xenakis’s line of argument here relates to his favored metaphor of the shell propelled from a cannon barrel: the energy and structured integrity of the driving impulse is modified by the nature of the boundary conditions which are brought to bear. It is, however, conceptually novel to recognize that these boundaries may assert themselves either by constraining or by unleashing variability.”

Roger Reynolds, *Xenakis: Tireless Renewal at Every Instant, at Every Death...*
(Reynolds, 2003).

Energy in Albert Einstein’s general theory has a link with the conceptual idea I have of energy in a piece. It is directly connected to the property that must be transferred to the composition object to exist within the thought experiment mechanism explained earlier (1.2.2).¹⁰ I think materialization of a piece is one transformation from an internal and abstract object into a societal object (Tremblay and McLaughlin, 2009). This is the moment and the place, the tipping point, where time and space become one. They confront each other with a real representation. The energy of the lines is deployed from the con-

⁸It does not matter if I do not use bijective functions because I will later do a mapping that does not require to come back to the initial choice of coordinate attribution.

⁹We will later see that both Isaac Newton’s and Albert Einstein’s theories are used in my process. One deals more with continuity and the other discrete elements (1.4.1).

¹⁰It may here eventually be one sort of code art.

cept. We see this for algorithmic art and generative art more specifically. But in my case, time and space were not defined initially. So the deployment also defines real-time and real-space. I here insist on the act of defining because I personally do not want it to literally be linked with nature and truth; this is no science. It rather comes from how the act of presentation is received by the audience; purely social. Karlheinz Stockhausen's *Mantra* is a very esoteric piece. It works perfectly without any explanation of its structure; it is taken as a unitary system, as a whole. The piece works perfectly and is therefore universal in itself.¹¹

Reading as part of a materialized piece



fig. 1.9 - *Dessiner sur Papier*'s structure from the entrance of Ircam's Espro.

Dessiner sur Papier is a piece for the *Nuits Blanches Paris* 2013 as a composer. This yearly event is the occasion for anybody to discover art pieces shown in the entire city during the whole night. It was presented at the Ircam's Espro.

The piece consists of graffiti drawn all night onto a paper Möbius strip. The structure is supported by a tall metallic structure from the ceiling. The infinite property of the form is conceptually interesting and also allows the performer Thorsten Streichardt to always draw on the same side. Visitors are invited to stay outside and watch him improvise from both sides. Each hand is equipped with two pencils and attached contact microphones used for amplifying and delaying scratchy sounds of the paper ring. Those sounds are diffused and spatialized using twelve tiny mounted speakers glued onto the paper strip. Sounds are repeated and triggered by noise gates quantized on a time grid, making poly-rhythmic phrases. The performer can erase the memory of the delays by hitting the two pencils together.

¹¹In 2017, there is no unitary law in physics either. No actual link between general relativity, dealing with gravity, and quantum mechanics, dealing with elementary particles, has been found. There are theories (string theory, loop quantum gravity, and so on) but they remain theoretic composition systems.



fig. 1.10 - Writing on a paper möbius strip in *Dessiner sur Papier*.

This piece is a möbius strip for many reasons. Writing live in front of an audience is a performance mixing present with past; thanks to the traces the audience can still read while listening to the sounds of the present. Also, the piece is a system and that system is the piece: a loop in the concept shows a piece being infinitely re-materialized. There is then a paper loop in the space, a “thought” loop in the concept and a time loop in the system.

Dessiner sur Papier shows time and other composition parameters are intricately connected and even mixed for the audience. The scrambling of all available parameters is here the point of the piece. As for *Kaspar*, an immutable paper medium invites the audience to read. The act of reading sets the mind into a peculiar state of concentration which elaborates a subjective thought experience. That experience comes from an imaginary materialization of the piece represented on paper (1.2.2). There is no necessity for the piece to truly become real and have any particular projection into the “real-world”.

This is one reason why for me *Kaspar* and *Dessiner sur Papier* are not multimedia pieces.

I often make a connection with Kas Oosterhuis’s idea of *non-standard* architecture, in which the object has no plan to exist in reality and is a proof of concept, the outcome of a thought experience. This allows imagination to go as far as possible beyond material and time limitations (Oosterhuis, 2009; Mennan, 2008). The construction is a body, in relation to the musical object described earlier. This body and its materialization have no standard time-line or space-line. It can be constructed in real-time, designed after its existence, generated from variable parameters and so on.

Fixative and re-fixative kaleidoscopic reading modes

fig. 1.11 - *The Mystery of Picasso* in which Pablo Picasso draws live. I started to compose the music for the 40th anniversary of the director Henri-Georges Clouzot's death who made the movie.

Reading a musical sequence is done by alternating saccades and fixations. Saccades are the rapid movements of the eyes while fixations are relatively stationary. This succession of movements and its characteristics show how we read musical scores. I believe these gestures clearly materialize the spatial computation I describe in the section 1.3.3. They are a physical consequence of the way we read with physiologic limitations. It goes further with the movement of refixation which is a back-and-forth in the reading. This visual process does not travel in time, but rather within the intricate structure of what is thought to be a notation.

A hierarchy of elements indeed depends on personal focus and whether the piece is being performed or read. When being read, the public gets full freedom to decipher; limits reside in the public imagination. But when elaborating the piece, even “non-standard”, there always are limitations in the reasoning or physical body (Hofstadter, 1979). These constraints show the existence of hierarchies which were not initially intended. I personally see this characteristic as primary and we will later see, in the section 2.2, how it has become part of my creative process as a confrontation with reality. This hierarchy, intended or not, is a necessity for segmentation and then proposing comparisons. These comparisons are one specific moment of the creative process. They are also other possible times for the reader. The mechanism of comparison (differentiation or proportions) is a back-and-forth movement of the eye or the memory. Its physical connection shows that our brain is supposedly designed for processes inspired by nature. These comparison processes are kaleidoscopic modes when used within the art piece.

The Mystery of Picasso from the director Henri-Georges Clouzot is a good example. Commissioned by the Cinémathèque de Paris, the piece, played by the

pianist the pianist François Régis, is a new music for the movie *The Mystery of Picasso*. The project got delayed in order to coincide with the 40th anniversary of the director's death. The piece is made of interconnected layers of hierarchies between Pablo Picasso's drawing, Henri-Georges Clouzot's filming, the music and finally the public. These games of hierarchies are enhanced by the fact Pablo Picasso draws his painting live. This adds another time dimension to the mode of reading the piece. The movie is then full of fixative and re-fixative reading modes. In the movie, Pablo Picasso himself sometimes stops painting and gets a look back. He gets the same external point of view as from the public. An extra layer of complex hierarchy is even added when he paints onto transparent glasses. Instead of projecting 3d symbols to a plane like for *Kaspar I*, we here cast the views through several filters through several types of times.

The hierarchy described here gives a sense of determinism, an order of importance and levels of consequence, in the pieces presented in this text. (Anderson, 1972). If composing with several media, one of them can be at the service of another. For instance, the amount of importance between music and image in *The Mystery of Picasso* or a theater piece like *Songes et Métamorphoses*. But the public is again here free to explore the information in any order of importance. This exploration could be seen as a very special type of score for electronic music.

1.2.3 Score for electronic music

This exploration, active listening, can also happen together with active watching. Reading therefore takes on a new dimension and redefines the existence of the score for pure electronic music: virtual score as multidimensional object. The score is neither prescriptive nor descriptive. It is a parallel work used for inspiration and sometimes offered for contemplation by the audience.

Needs of a score and notations for pure electronic music

“Conventional musical symbols cannot be used for writing down electronic music. The multiplicity of electronic shaping elements goes far beyond the graphical powers of representation of our notation. It is necessary therefore, to take into account the differentiations of electronic music not known in earlier music, by means of a notation which will correspond to the acoustic processes. This cannot be accomplished by any extension of the traditional notation, which suffices, at most, for the writing down of quarter or sixth tone music.”

Problems of electronic music notation from Herbert Eimert, Fritz Enkel, Karlheinz Stockhausen, (Eimert et al., 1954).

Herbert Eimert, Fritz Enkel and Karlheinz Stockhausen in the mid-1950s explicitly wrote that conventional musical symbols cannot be used for writing down electronic music (Eimert et al., 1954).

They talked about the need to find a way to incorporate electronics within scores. The multiplicity of electronic shaping elements goes indeed far beyond the graphical power of traditional representations of notation. As an example, even though he was not writing electronic music, Olivier Messiaen’s score of *Timbres-Durées* shows its limitations; symbols for timbres only make use of traditional rhythmical notation.

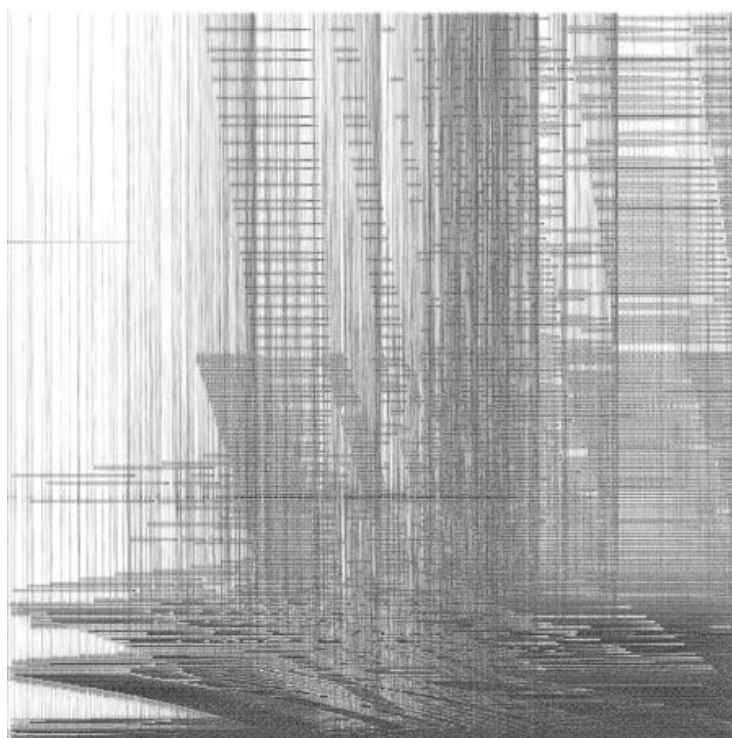


fig. 1.12 - *The Nothing, Seeking Answers: Indivisible Streams*’s rearranged sonogram.

The most popular solution is a notation corresponding to determined acoustic processes or their cause. Many printed scores have an extensive preface which describes the electronic part alongside other specific elements of the piece. Another solution takes the question the other way around; it consists of graphically writing in the form of an “acoustic” representation using data visualization. See the overall spectral form of *The Nothing, Seeking Answers: Indivisible Streams*’s sonogram 1.12. Panayiotis Kokoras, for instance, uses simple spectrograms in

his scores.¹² This technique is quite efficient for conveying an idea of how it sounds just by looking. Another solution is to decide that electronic music does not require a different notation paradigm from the traditional one.

Those propositions are used for mixed music using live electronics. It is interesting to think of what a score would represent for pure electronic musics which do not require instrumentalists.

Mechanical score to be interpreted

I see reproduction as a shift; a transmission, sometimes a transfer, of information from one concept to another, from concept to reality and from one medium to another. The passing from concept to reality is made by an automatic mechanical robotic system that processes thought and matter together, physically and electrically (Apter, 1969; Pressing, 1990). This is hence one single body, interfacing imperfectly, translating, or copying, information (Giavitto et al., 2015):

“Objects are placed in the regions defined by the membranes and evolve following various transformations: an object can evolve into another object, can pass through a membrane or dissolve its enclosing membrane.”

Computation in Space & Space in Computation from Jean-Louis Giavitto, Olivier Michel, Julien Cohen, Antoine Spicher, (Giavitto et al., 2004).

I believe there is an analogy here with human cultural background built up from learned imperfection: if such a reproduction mechanism contains culture, then active listening is interpreting because it the action changes or translates the heard music. We have seen earlier, I was also considering progression and transformation as a composition engine (1.2.2). I consider these reproduction mechanisms of engines for playing, composing and also interpreting: an artificial interpretation without human intervention.¹³ The entire traditional information chain for instrumental music is here reduced to one single black box (1.3.2).

¹²See *L'emploi Du Spectrographe Acoustique Et Le Problème De La Partition en Musique Expérimentale* from Abraham Moles and the work of the composer Vladimir Ussachevsky in 1957 (Moles and Ussachevsky, 1957).

¹³There may be a link here with cybernetics (Ashby, 1956).

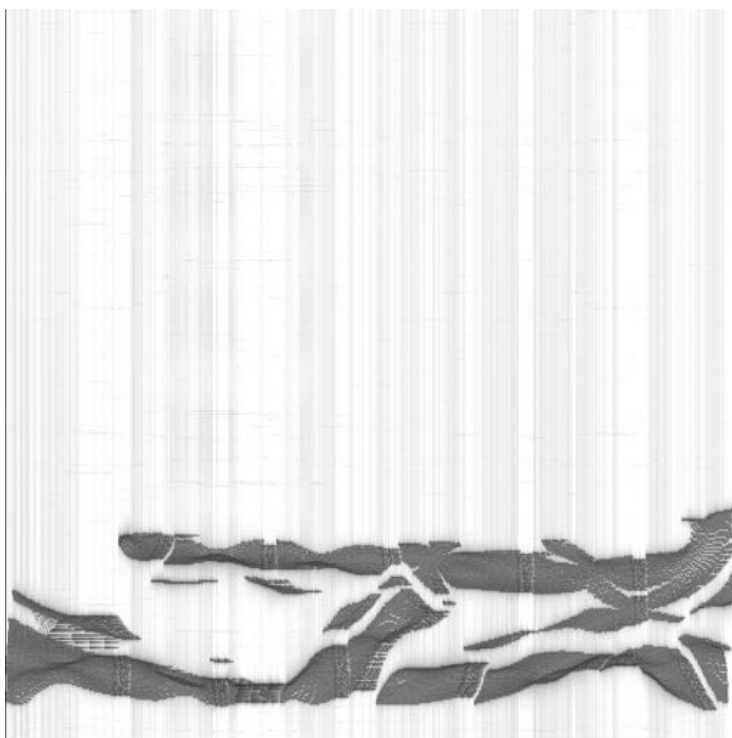


fig. 1.13 - Sonogram of an untitled etude rendered with Csound and my Python version of AthenaCL. Tiny grains with same pitches follow each other like piano trills would keep a note for a longer time. Vertical lines are unwanted clicks I can later decide to keep.

Algorithmic instructions are notated into a language using symbols representing qualitative and quantitative instructions. This language can be interpreted and performed by a machine. Using a language better fits human thinking in regards to reading and writing algorithmic processes. It is a way of communication between humans and machines, another interface open to interpretation. But the machine itself can avoid any language and directly use its own representations of music in a machine language which closely resembles its iterative transformations.

A machine alone still has no feeling and thus no particular interest in performing a piece. Its performance has no other purpose than to be received, then interacted with, or by, human agents.¹⁴ The score that interests me, made by humans or not, is always a mirror of human activity and dedicated to be read by humans (1.2.2).

¹⁴It can be done by tangible frictions onto membranes.

The question of descriptive scores

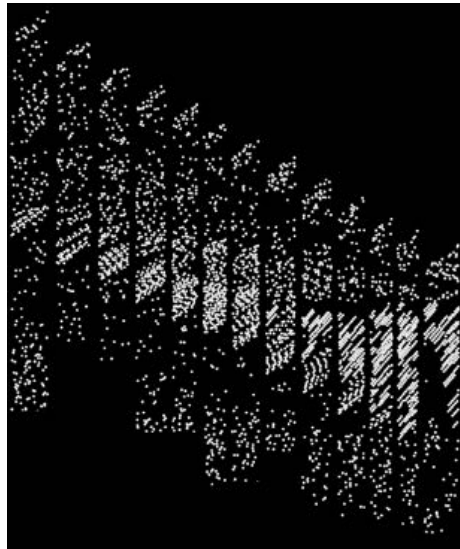


fig. 1.14 - Zoom of *Perfect Time* (fig. 1.16); an early piece offered to the City of Tokyo for the 2011 earthquake.

Charles Seeger in *Prescriptive and Descriptive Music-Writing* differentiates prescriptive from descriptive notation (Seeger, 1958). Prescriptive notation focuses on how music shall be made to sound, while the descriptive one is more like a report of how a specific performance of it actually did sound. A score for pure electronic music is obviously descriptive. For example, a recording is a type of descriptive notation. It can be the documentation of a performance.¹⁵

We nevertheless see reproduction mechanisms contained in a cultural background that could also be considered as an interpreter, or interpretation. The code becomes a prescriptive score for the machine.



fig. 1.15 - Tree patterns generated for of *Kaspar I* that will later be displaced by aggregation. They are three dimensional reduced into two dimensions: the higher is the angle of projection is the closer are the unitary dots eventually forming grey lines.

I often invite the audience to engage in an active listening in my pieces. I suggest that they closely concentrate on the evolution of patterns as if they were

¹⁵Note that in the 1910s, the Second Viennese School, Arnold Schoenberg, Alban Berg and Anton Webern, were writing atematic music at around the same time that recording became commercially successful. The lack of exact melodic repetition is in opposition to reproduction given by the mechanical technology.

reading letters in a text; at a low level. This is for instance, what happens when carefully looking and closely listening to *Proxima Centauri b*. This conscious deciphering of patterns redefines my audio and visual pieces as auditory scores for the listeners.

It creates an apparent loop both for the definition and for how the music is represented.¹⁶ But this is just illusory because the overall pieces, alongside their scores, are conceptual pieces. They are the outcome of machine processes and therefore conceptual pieces. At least, their process is conceptual if not their result. The mechanism is purely conceptual and thus encompasses all times and spaces; there is then no question of causality, thus no question of description or prescription.

One such composer is Philippe Leroux, who distorts the causal gap by implementing textual and musical notation directly into his music piece (Voisin, 2011). The “text” is sometimes visible, sometimes hidden within the composition process:

“Voi(Rex) was composed using poems by Lin Delpierre, taken from a collection entitled Le testament des Fruits. The poems have been freely reordered, even mixed at times. The meaning of the text remains mostly understandable and contributes to the overall expression of the piece, but its structure also determines some of its features. The poems also serve as phonetic material and suggest several figuralisms scattered throughout the piece. The very calligraphy of the letters, as a cousin of the melody archetypes that are sound-waves, is used to generate rhythmic/melodic models and spatial trajectories. Finally, some scenographical movements borrow stylistic and punctuation traits from the poems.”

Program note for *Voi(Rex)* from Philippe Leroux, 2001-2002.

Exactitude and determinism

My work does not need correctness for a public that is invited to engage a subjective active listening. It nevertheless needs exactitude from rendering in order to provide the most information possible. There is also a choice in the aesthetics. A sufficient resolution of the medium indeed allows me to play with perception and the limits of understanding (1.4.2). There is also the egoistic and cultural pleasure of constructing something in its entirety; from its very bottom... The best examples are maybe the visual piece *Perfect Time* printed on paper or my video piece *Fomalhaut Γ* shown fig. 1.16 and fig. 1.17.

¹⁶We are here not far from Kurt Gödel’s incompleteness theorem (Hofstadter, 1979).

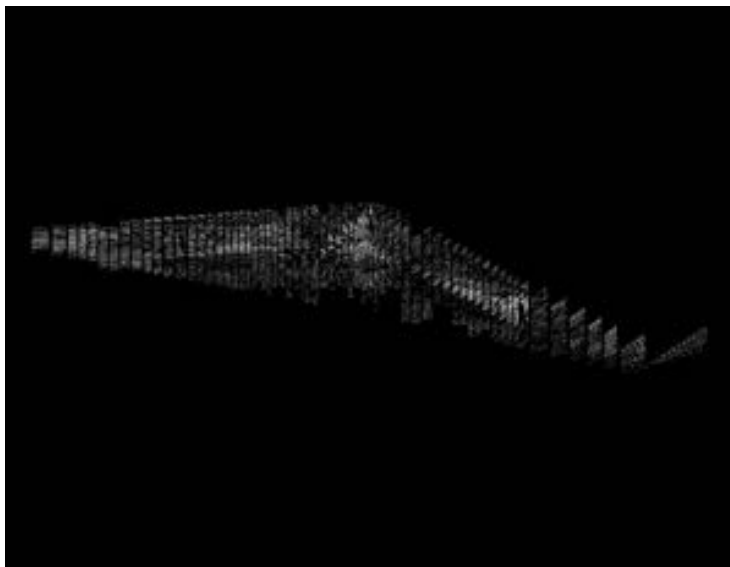


fig. 1.16 - *Perfect Time*, from 2011, shown here as an early piece. A zoom is shown at fig. 1.14.

Sound produced from a recording is almost an exact transduction. This is more intricate with computers because they have the ability to capture, move and change information unlike recordings (Boulez et al., 1981). A more systematic score is needed for non-linear algorithms that are designed to change over time. Lejaren Hiller, for instance, was a pioneer in composing straightforward graphs (with sometimes some amount of randomness) describing sequences of musical events, in the 1960s (Hiller, 1982). He is aware of the limitations of a purely stochastic system in the case of some composition approaches:

“Should provision be made for transition probabilities between parameters? For example, given a certain rhythm, what are the probabilities for a certain set of pitches, and so on. It should be recalled that I said earlier that subroutine STOCH contains no a priori assumptions regarding interdependence of note parameters. Clearly, this is a simplifying assumption that does not accord with normal musical reality. Common experience dictates that rhythmic choices, position in a bar, and many other factors influence pitch choices, and vice versa. This was demonstrated in statistical studies I made a number of years ago of music by various composers ranging from Haydn to Webern.”

Lejaren Hiller, *Stochastic Generation of Note Parameters for Music Composition* (Hiller, 1982).

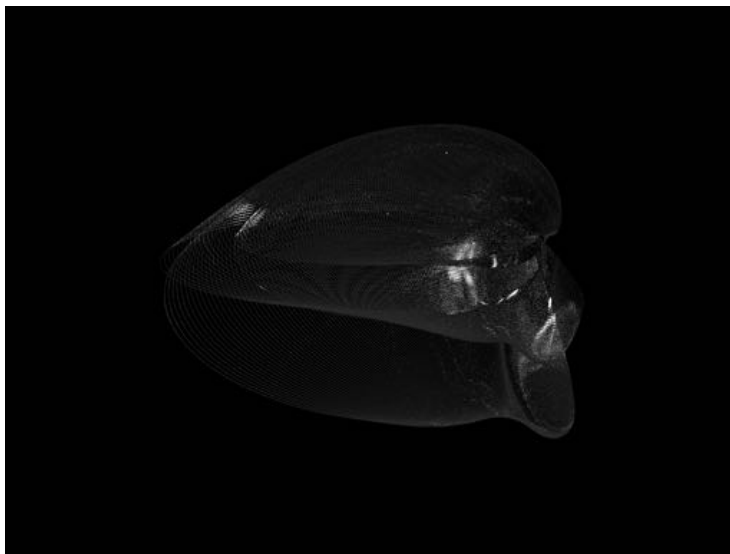


fig. 1.17 - Another snapshot of another version of *Fomalhaut* Γ .

I personally have never seen any adequate standardisation for electronic scores. Every case depends on the composer, the piece and the public reading it. In my case, the concept is within the score and therefore cannot be generalized. I believe this is the difference between software and artistic code (code art?).¹⁷ This is the reason I am working on concepts which are not meant to be generalized; they are non-deterministic and only accurate from an artistic point of view. That accuracy would sometimes lead to a style. John Cage provides beautiful examples of scores where freedom is given to both instrumentalists and listeners (Cage, 1969).

Some very interesting artists do not use machines in their art. They use hand-made irregularities to write recurrence and programmatic thinking. For instance, in , Gregor Mobius shows sequences of nucleotides using plausible permutations drawn by hand (Mobius, 2013).¹⁸ Roman Opalka also wrote patterns by hand. Also see the work of Japanese conceptual artists like On Kawara or Yayoi Kusama. He painted numbers from one to infinity between 1965 until his death in 2011. In addition, he recorded himself counting out loud, giving an audio part of his work. Both the counting and his lifetime are part of his work like a global piece: his personal research.

¹⁷If one of my pieces could be totally generalized, it would have a maximum redundancy and its compression would be reduced to its minimum entropy (1.3.3) (Thornton, 2009).

¹⁸The fact he does everything by hand gives a peculiar sense of craft, and composition to his book.

Synchronicity of virtual scores

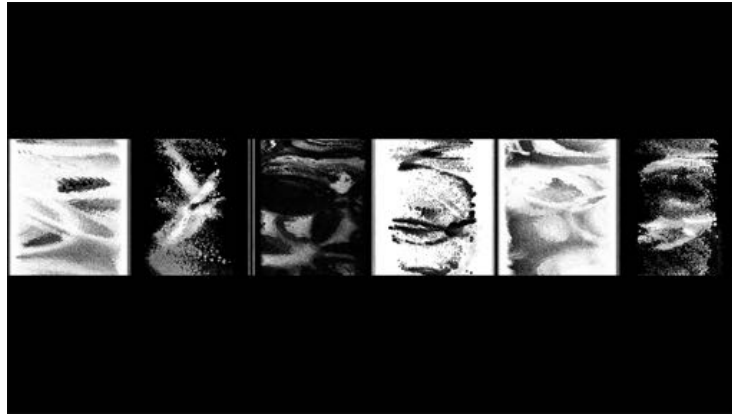


fig. 1.18 - Snapshot of the video *Proxima b1*, 2017. The piece is composed for three tiny 4k screens and three speakers. There is a clear polyphonic game of correlation between the three parallel screens sometimes themselves divided. It is the same with stereo panning for the audio part.

Philippe Manoury designates non-linear computer scores as virtual scores (Manoury, 1997).¹⁹ The Markov chains he uses are rather intuitive for mental representation because they use probabilities and discrete state spaces. The approach fits with time-based music and therefore makes a convenient link between sequential concepts and reality (1.3.4). These processes run as long as needed: time it represents can freely bend and inter-connect with external factors and inner subjective awareness. The more complex durations as combinations of fractions, the more subjective appreciation of them is relative; and times feel shorter or longer.

G rard Grisey’s *Tempus Ex Machina: a Composer’s Reflections on Musical Time* makes reference of this link as a punctual instant when sequences are applied to real-time (Grisey, 1987). It is for me when the magic happens; I usually compare it with “presenting a baby to its mother”:

“Without a reference pulse we are no longer talking of rhythm but of durations. Each duration is perceived quantitatively by its relationship to preceding and successive durations. This is the case in the rhythmic writing of Messiaen and of the serialist school. In fact, a micro-pulse allows the performer or conductor to count and execute these durations, but it only exists as a way of working and has no perceptual reality.”

“The notion of smooth (unmeasured) and striated (measured) time described

¹⁹We here notice Philippe Manoury’s very initial creative spark is randomness at least for the electronic part of his music 2.3.2.

by Pierre Boulez” (...) “is merely the invention of a conductor bereft of any phenomenological awareness. Who perceives the difference between time divided up periodically by a meter” (...) “or, if one prefers, by a virtual pulse maintained by the composer/musicians - and smooth time, without a pulse, if the rhythms which overlay it are there precisely to destroy all feeling of periodicity?”

G rard Grisey’s *Tempus Ex Machina* (Grisey, 1987).

Synchronicity can be a primary concern when the concept and reality are irregular between one another. Variations over time indeed need to be part of the composition and consequently controlled. The permeable membrane between concept and reality is a major subject of instrumental music using live electronics. Manoury and Miller Puckette first explored automatic score following in *Jupiter*; a piece for flute and live electronics from 1987 (Manoury, 2010).²⁰ Barry Vercoe was also pioneering on that subject around the same time. 30 years later, we are confronted with the same questions, but there has been some progresses with for instance followers and languages like Antescofo. The string quartet *Netivot* for which I did the electronic part in 2016 uses it with the four instruments in parallel (fig. 1.19). Synchronization deals with parallel processes and multiple times. It is similar to a transfer or percolation process and needs a specific type of language and real-time notation (Halbwachs, 1993).

²⁰They used *pt~* with *detonate* in Max. Chuck or SuperCollider are very adapted for time-based processes too but for different purposes (synthesis, live coding).

```

1  @FU_DEF beat2msec($X) {
2      1000*$X*60.0/$RT_TEMPO
3  }
4
5  @FU_DEF beat2sec($X) {
6      $X*60.0/$RT_TEMPO
7  }
8
9  ; A function that uses the internal random() function that outputs random values between 0. and 1.
10 ; The random value here is tweaked to generate a MIDI pitch number using a controllable
11 ; range and offset value.
12 @FU_DEF MIDIrand($range,$offset) {
13     ($range*@random()+$offset)          ;@ceil
14 }
15
16 VARIANCE 0.3
17 BPM 112.00
18
19 ; BARS NUMBER START AT MEASURE 52
20 ; ----- measure 67 beat 0.000 -----
21
22 TRILL ( ( 7200 5300 4800 ) ) 1/2          bar_67
23 antecue 2
24 CHORD ( 7200 5300 4800 ) 5/6
25 CHORD ( 7200 5300 4800 ) 2/3
26 NOTE 7100 0.000
27 CHORD ( 7200 5300 4800 7075 ) 1/2
28 MULTI ( ( 7200 5300 4800 7075 7175 )->( 7200 5300 4800 7075 7025 ) ) 1/2
29 MULTI ( ( 7200 5300 4800 7075 7175 )->( 7200 5300 4800 7075 7025 ) ) 1/2
30 CHORD ( 7200 5300 4800 7025 ) 3/4
31 CHORD ( 7200 5300 4800 ) 1/4
32 TRILL ( ( 7200 5300 4800 7000 7175 ) ) 3/4
33 TRILL ( ( 7200 5300 4800 7175 ) ) 1/4
34 antecue 3
35 KILL 1.0s r1
36 CHORD ( 7200 5300 4800 7175 ) 1/2
37
38 NOTE 60          1.0
39
40 mnote @MIDIrand(8,64) 120 "4n"
41
42 ; This loop generates a random-pitched sequence but with controlled relative rhythm
43 loop r1 5.0
44 {
45     mnote @MIDIrand(8,64) 90 "4n"
46     1.0 mnote @MIDIrand(8,64)          90      8nt
47     1/3 mnote @MIDIrand(8,64)          90      8nt
48     1/3 mnote @MIDIrand(8,64)          90      8nt
49     1/3 mnote @MIDIrand(8,64)          90      "8n"
50     0.5 mnote @MIDIrand(8,64)          90      "8n"
51     0.5 mnote @MIDIrand(8,64)          90      "16n"
52     1/4 mnote @MIDIrand(8,64)          90      "16n"
53     1/4 mnote @MIDIrand(8,64)          90      "16n"
54     1/4 mnote @MIDIrand(8,64)          90      "16n"
55     1/4 mnote @MIDIrand(8,64)          90      8nt
56     2/3 mnote @MIDIrand(8,64)          90      8nt
57 }
58
59 5/7 loop r2 5.0          @tempo 60.0
60 {
61     0.0 mnote @MIDIrand(8,88) 90 "4n"
62     5/7 mnote @MIDIrand(8,76) 90 "4n"
63     5/7 mnote @MIDIrand(8,70) 90 "4n"
64     5/7 mnote @MIDIrand(8,64) 90 "4n"
65     5/7 mnote @MIDIrand(8,50) 90 "4n"
66     5/7 mnote @MIDIrand(8,40) 90 "4n"
67     5/7 mnote @MIDIrand(8,28) 90 "4n"
68 }
69
70 NOTE 60          1.0
71 KILL 1.0s r1
72
73 ; ----- measure 68 beat 6.000 -----
74
75 CHORD ( 7200 7075 7100 ) 1/1          bar_68
76 CHORD ( 7200 7075 7100 ) 1/2
77 CHORD ( 7075 7100 ) 1/2
78 NOTE 7100 1/1
79 CHORD ( 7100 7075 ) 2/3
80
81 ; ----- measure 69 beat 11.000 -----
82
83 TRILL ( ( 7100 7100 7200 7200 ) ) 1/1          bar_69
84 CHORD ( 7100 7200 ) 1/1
85 CHORD ( 7100 7200 7075 ) 1/1
86 CHORD ( 7100 7200 7175 ) 3/1
87 NOTE 7175 1
88 NOTE 0 3/4
89 TEMPO OFF

```

fig. 1.19 - The electronic part of the string quartet *Netivot* is synchronized using the Antescofo follower and synchronous language.

This paradigm often considers the score in a traditional way where the machine is socially at the service of human instrumentalists. It is reduced as an instrument. But synchronous programming languages can also be convenient for synchronizing parallel time representations within virtual scores themselves (1.4.1). It is the actual essence of synchronicity. Elements lose apparent causal relationships while keeping meaningful coincidences as Carl Gustav Jung defines it (Jung, 1960). I believe meaningful coincidences are both artistic choices and purely subjective judgments in my works (2.3).²¹ The topology of causality would only organize itself at this punctual moment of materialization and anything could interconnect beforehand (1.3.2, 1.4.3).²² I do not incite people to watch, or read, my visual compositions in a specific direction. But this is another issue with music. Entropy of time does not allow any change of direction. There is also only one dimension for time at our human scale; there can be scales though. There has to be a reduction of dimensions for the propagation topology of causality within real-time. This is one of the several reasons I compose a series of generative pieces allowing parallel comparisons. This also why I am using parallels with visuals and dare to call them score in a general way. One piece is often the instance of a more complex musical object (1.20).

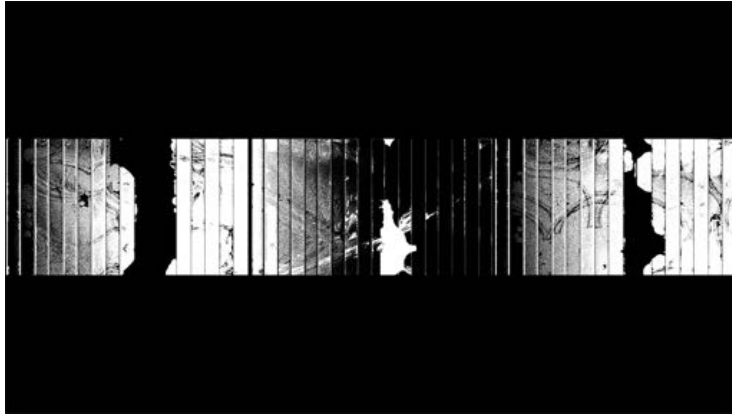


fig. 1.20 - Another snapshot of the video *Proxima b1*. This particular moment shows parallels between the screens and vertical lines.

²¹In physics and geometry, causality has the properties of antecedence and contiguity. This is not an obligation in my work since it is based on purely mental thoughts. For my case, $1+1=3$ would be plausible and I do not use computers as deterministic machines.

²²Depending on the point of view we are in, there is here a link with self-organization and emergence (1.4.3).

Iterative reading of patterns

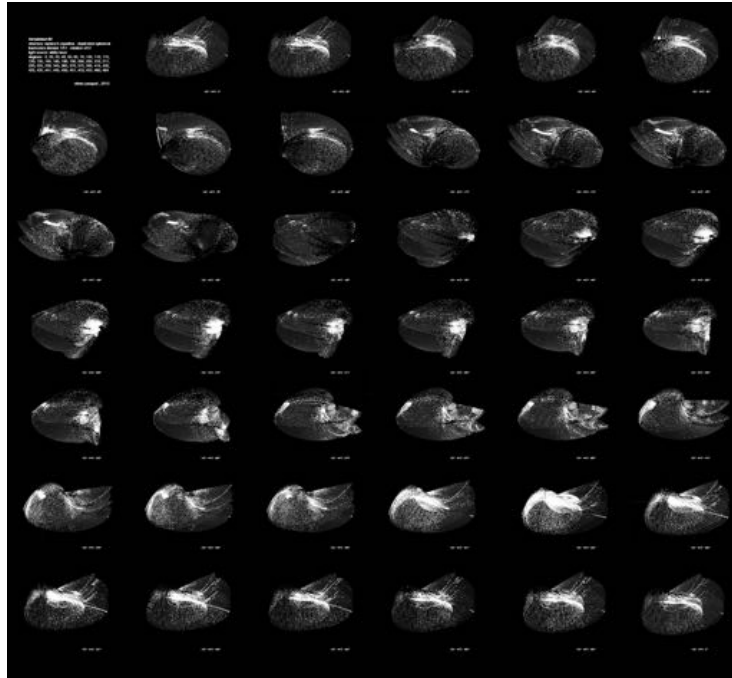


fig. 1.21 - Various of iterations for *Fomalhaut* Γ. You can zoom and see projected patterns from a 3d form.

I am well aware that my visuals do not look like actual scores such as graphic scores. They do not show the symbols necessary for information to be correlated. As explained before, my purpose and approach are both different (1.2.2). But I am also still far from the admirable visual composer Manfred Mohr, whose fixative passion for hypercube since the 1970s explores the power of dimensions and projections (1.2.1). I also admire the consistency, clever radicalism, of individuals like Pierre Soulage or Roman Opałka (2.3.2) (Buren, 1991). Such conceptual pieces are interesting beyond the actual composed patterns and forms in their drawing.²³ Throughout his entire lifetime, Manfred Mohr achieved a lifetime research, offering the public to not only watch his current pieces but also their historical context. One can follow interests and patterns within his entire work; his life work is a piece of art. One can “read” about the current pieces in a literature built by Mohr over his body of work, by analysts and the public itself. Each step of exploration is for me an iteration: reading a piece, or examining a context which is part of the piece. The whole piece is multi-form.

²³Again here, my definition of conceptual art varies from Robert Morris’s and is more procedural like the one of Sol LeWitt’s (Norvell, 2001).

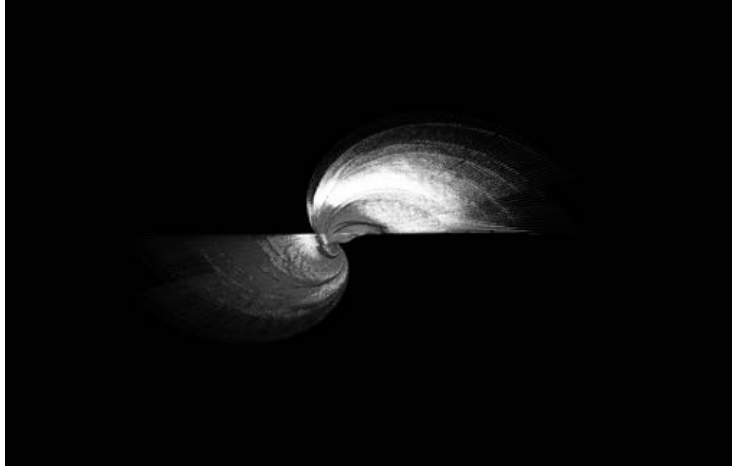


fig. 1.22 - Snapshot of the audio-visual piece *Fomalhaut Γ* : a printed rotating sculpture made of chrome reflects rhythms from a bright white laser.

My piece *Fomalhaut Γ* is a multi-form piece created in 2015. One of its versions is shown in fig. 1.22 and in an installation context in fig. 1.23. The piece consists of a series of spatial compositions called: *hr 8799a*, *hr 8799b*, *hr 8799c*, *hr 8799d*. They can be presented onto various media such as on paper, video or even as a metallic sculpture.²⁴

The piece offers people to discover the audio-visual spectacle of an aggregated self-organized universe. It has its own rules and follows its own history (Luminet, 2013). A white laser is projected onto a complex structure made of chrome which reflects 3d spatial patterns and micro-rhythms from very strong contrasts. The multi-channel sound uses envelope spatialization and is closely linked with the laser from the same generative system (1.3.3). Visitors are set in a very dark environment where both lights and sounds are dim. This forces them to carefully decipher the information as in *Kaspar I* (1.2.1). The metallic structure can be considered as a composition constraints and the laser as a mapper as for video mapping. Infinitesimal grains create an optical flow I can drastically slow down at the boundary of perceptive landmarks and auditory memory.²⁵

²⁴This specific type of multi-form piece is not a new story. *City of Flowers* indeed had a similar approach at the EArts Festival in Shanghai. I have recently been commissioned a similar piece for February 2018 at the Toshiko Mori's Greatbatch Pavilion in the Frank Lloyd Wright's Darwin D Martin House Complex located in Buffalo, NY.

²⁵Using Twixtor in the case of video and the SuperVP phase vocoder for audio.

fig. 1.23 - Disposition for *Fomalhaut* Γ .

1.2.4 Transition

Audio-visual takes an important place my work. It is present in the outcome, but also in the composition process itself. It does not depend if the piece is a music piece or a visual one. But in all cases, I invite the audience, readers, to interpret the composition as a special score, where the symbols may be deciphered independently in space and time. The fact that representation and presentation are one allows me to merge available times and spaces and conceive them as a psychological experience. They only become separated at the crucial moment of performance or presentation. One question resides in how I build, conceive and compose the skeleton of my pieces consisting of minutial elements that could be understood as a complex alphabet.

1.3 Parametric and computational composition

Audio-visual interconnections led me to specific approaches that I did not intend to be general. I decided to use geometric curves I could later map to signal controls. Inter-connected together, those curves built symbolic object forms.

1.3.1 Parametric composition

I use concepts that can later be applied to various fields and different points of my creative processes. I therefore need to formalize ideas from a level low enough I can later build systems that will spread autonomously. We have seen earlier that I was using computational composition systems and the best way consists of formalizing, or perceiving, concepts into a system that can later be controlled by a series of variables (1.2.3). The piece deploys itself when specific times are applied to these variables controlling the system. They encode and clarify the relationship between an intended system and its outcome. They control the materialization transfer of the concept thought with a representation and generalization of curves through equations, as functions. Each function evolves within a space where coordinates are mapped to composition elements, factors. That space is a manifold and depends on the needs of representation for a specific task in the composition process. From a timed perspective, present is located at a punctual position of a specific space. From a spatial perspective, distinct positions appear at one specific moment. I am here applying an idea used in parametric architectural design in a wider field for composition.

1.3.2 Parametric composition and mapping

Spatial processes build evolution with trajectories. The latter are described by geometric and linear algebra tools. Projection, the point of view seen earlier, allows me to map interconnected curves to synthesis and rhythmic parameters.

Trajectories as progressions

Chosen spatial processes encourage the public to comprehend my pieces in a musical way where evolution of space and time are primary. We have seen in 1.3.3 that movements therefore need to be quantized in order to be able to separate and compare information at any scale. I experimented with a wide range of approaches using discrete models, for instance, ray-tracing techniques or tessellation models influenced by John von Neumann's idea (Stiny, 2006). Von Neumann designed a self-reproducing machine, a universal constructor. He also explains that some mechanisms are based on ruled shifts of position enti-

ties (von Neumann, 1966). That approach fits perfectly with my interests and it would be useful for the generalization of systems using spatial computing. He here describes the idea of multi-agents:

“There is no question of producing matter out of nothing. Rather, one imagines automata which can modify objects similar to themselves, or effect syntheses by picking up parts and putting them together, or take synthesized entities apart.”

John von Neumann, *Theory of Self-Reproducing Automata*, (von Neumann, 1966).

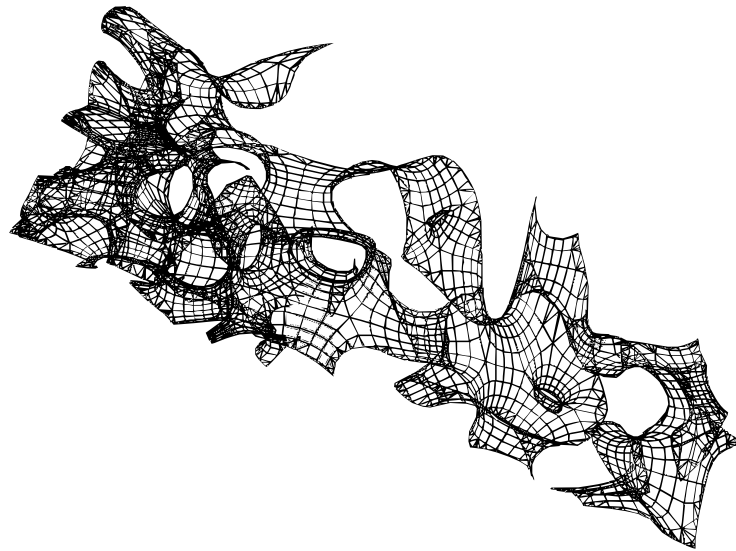


fig. 1.24 - Mesh of a minimal surface I made with the Rhinoceros 3d software inspired by Frei Otto. The mesh can be considered as the interrelation between trajectories.

Unfortunately, these processes have no true interesting progression for composition at a large scale. For instance, a random fluctuation that has no visible redundancy seems nevertheless uniform. It can make large and obvious movements and still look continuously... random. Using a spectrum representation is the way to watch this. I think this lack comes from the fact that such automatic construction needs to have a sense of memory. I believe the emergence from previous states is a required characteristic for “musical” progression. Musical evolution should lead either somewhere or nowhere; it should be a lead for the audience: a trajectory, and a trajectory in discrete mathematics is a sequence. I went much further into Stephen Wolfram’s very inspirational ideas described in *A New Kind of Science* (1.4.3) (Wolfram, 2002):

“In a cellular automaton of finite size, every trajectory must eventually be periodic, or must merge with a periodic trajectory. In practice, the length of the “transient” before a trajectory merges is typically about $\leq N$.”

“Cellular automata may be used as mathematical models for physical, biological and computational systems. They are simple in construction, and thus potentially amenable to precise mathematical analysis, yet are capable of complicated behavior. This article has outlined a first step in the analysis of the (non-equilibrium) statistical mechanics of cellular automata, and has described some generic features of their behavior, such as the formation of particular self-similar patterns. Further investigations along these lines may reveal general universal features of irreversible and non-equilibrium, statistical systems analogous to those found in equilibrium reversible systems.”

Stephen Wolfram, *Cellular Automata as Simple Self-Organizing Systems*,
(Wolfram, 1982).

I nevertheless sometimes consider sequences as continuous in order to use them as descriptive entities. I therefore can use geometric curves as a topological space (1.4.1). The latter is later connected to parameters for materialization. This is simply data mapping.

Trajectories are obviously also commonly used in architectural design (Ano, 2010a,b). This is one reason I often make parallels with architecture and use its techniques. It could also well only be particles physics using Feynman diagram or even aerobatic Aresti notation.²⁶ The two strong links between my approach and architectural design are representation and space inside which the audience stroll, progress and even sometimes is part of the overall topology.²⁷

Association and mapping with parameters

I actually connect data models many times in the creative process. Generally associating data sets with continuous functions are often the essential construction element of the piece (Mazzola, 1987). For example, using large sets of speakers. Mapping also consists of taking the artistic decision of connections between data or parameters. The system can be linear or non-linear, with or without, bijective connections with only one solution at a time, associating parameters still remains a difficult task which depends on multiple subjective reasons (2.3.1) (Beilharz, 2003).

²⁶Aresti notation’s strength for us is the link between gesture and real physical movements.

²⁷It seems I use a lot of inspiration from history of science. This is because of my naive naturalist and expressionist desires for an artificial nature (2.3.2). But when digging a little more, one can see nature is just a pretext (Prusinkiewicz and Lindenmayer, 1990).

Olivier Messiaen said there has to be two sounds or one sound and a silence for music to exist. Le Corbusier did not define his Modulor principle of proportion by chance. His anthropometric scale maybe comes from the omnipresent and universal use of ratios in all Japanese buildings linked with power or religion (Shinto or Buddhist).²⁸ They both make mapping the core of their ideas. It is so important it eventually defines the existence of their piece itself:

“In reality, the Modulor is a tool that helps one to “tune” dimensions to each other just as one tunes the strings of a piano. It does not help one to determine sizes, but rather to arrange them, to prevent them from being in arbitrary relation to one another, to make them adjust precisely to one another, to bring them together in one single family. It is this “single family” that gives a strange unity to any composition made with the Modulor. The apartments of the Marseilles Unité were designed with just fifteen different dimensions, and these can be found repeated and harmonised with one another everywhere, as in a living being created by nature.”

Le Corbusier, *Le Modulor* (Le Corbusier, 1950).

This complex system of inter-relations could for instance be formalized using set theory (Dorin and McCormack, 2002). But I actually do not plunge into such tools without real artistic means. By artistic, I mean there is the existence of external influences, factors that avoid me using strict formalization (2.2).

I rather consider mapping as an association as much as the idea of projection or the synchronicity between events or parameters. I use it as an act of making meaningful coincidences: as a notion of concordance (different from consonance) which is defined both qualitatively and quantitatively (1.2.3). *Etude r136b* and *Etude r136b* clearly show the simple relation between elements I am trying to reach: fig. 1.25, 1.26.

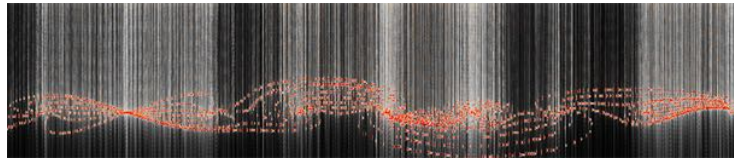


fig. 1.25 - Sonogram of the etude *r136c*. This version comes from a system of attractors controlled manually.

²⁸Every single detail was build with only ratios from the initial Ken unit ($1+\frac{9}{11}$ m).

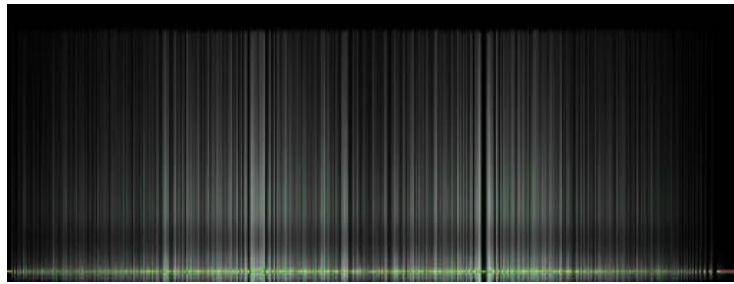


fig. 1.26 - Sonogram of the etude *r136b*. Rhythms of this monotone piece are generated using Rhinoceros 3d and Csound.

These etudes are build with Rhinoceros 3d and Csound. Rhino is a powerful design software for generating forms using a huge variety of techniques used in computational design (fig. 1.27). The fact it uses Nurbs for curves and surfaces perfectly fit with my way of thinking. Nurbs can have complex, organic shapes and are controlled by points influencing their directions. I later implemented a personalized version of AthenaCL inside for building more straightforward mappings in Python (fig. 2.22). I also added the possibility to generate midi tracks controllers in Ableton Live so I can use them within a productive environment when I need to compose efficiently: fig. 2.22. All those curves are all in relation and mapped later to a large variety of synthesizers. Chosen syntheses are based on a simple additive synthesis making an “acid” sound using a frequency sweep as an attack. Some other time, frequency modulation.

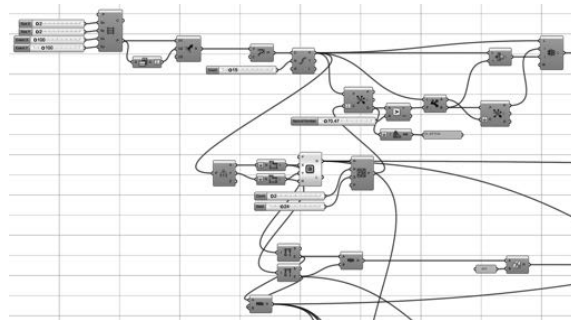


fig. 1.27 - Zoom of the Rhinoceros 3d (Grasshopper) allowing me the placement of points that later become musical events in *Forma*.

fig. 2.22 - Python code extract for mapping generated patterns into a midi file using a personalized AthenaCL.

fig. 1.29 - Coordinates from Rhinoceros 3d are converted into midi notes and data coming from my AthenaCL are converted into midi controllers.

Differential procedures and fields for articulations

Iannis Xenakis working for Le Corbusier's office positioned hyperbolic paraboloids of the *Philips Pavilion* in a way visitors can see perspectives both from inside and outside (Pasquet and Codognot, 2009). The projected perspective projection only has the effect of reducing the number of dimensions and majestically underlining connections between curves flattened inside the eye.²⁹

Energetic lines and Nurbs I described earlier are part of an associative complex system. We know their qualitative characteristics, but we also need to know their relative evolution (1.2.2). These consequent associations are quantified with a difference or ratio (phases or proportions) between states. For the music I am interested in, we are focused on changes. As a simple example, Markov chains analyse and manipulate transitions between discrete pitches rather than pitches themselves. A Markov chain indeed is a model describing a sequence of events in which the probability depends on the state of the previous event.

I similarly need a way to connect trajectories of parameters between each other. I then need a functional object in a multidimensional Cartesian coordinate system which totally describes the interactions between those parameters (fig. 1.30, 1.31) (Dzemyda et al., 2012).

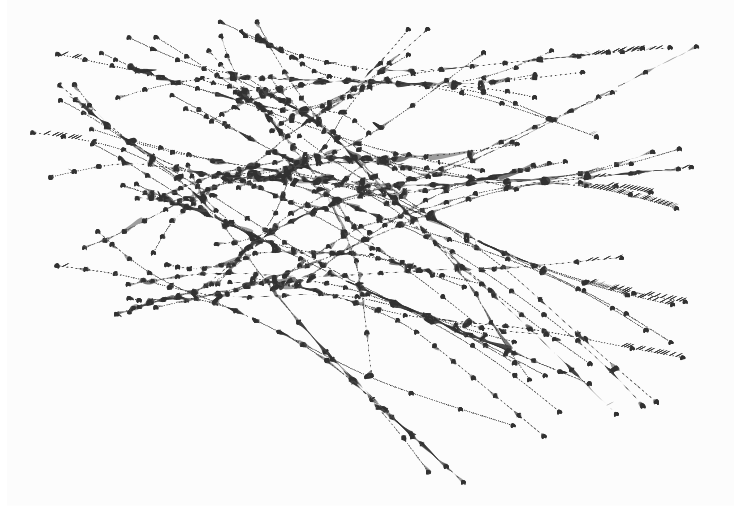


fig. 1.30 - 3d curves as topological space deviated by point and line attractors using splines. These ones were used for the piece *Forma*.

I noticed that a set of derivatives, either geometric or parametric, at several orders shown to be good descriptors for a functional curve. I could have used

²⁹With such projection, readable information is reduced but not the actual data: there can be overlying. By generalizing the idea, that sort of reduction of information within a same space has a strong link with entropy.

the moments but I consider these curves more as functions than signal. The piece *Forma* is full of modulated parameters converging to a set of randomly chosen other parameters (fig. 1.30). This approach allows me a straightforward comparison between curves using descriptive functions. This is the degree of change, the *Reihen der Veränderungsgrad*, the levels of transformations, Karlheinz Stockhausen uses in his piece *Kontakte*. There are series of change, from a zero change to maximum change, series of derivatives. Each series is grouped as a field following one predominant parameter and transforms processes from quantitative to qualitative compositions. The predominant parameter is an *attractor*. He explains it here:

“Consequently, the structure of the piece is not presented as a sequence of development in time, but rather as a “direction-less time-field”, in which the individual groups also have no particular direction in time (as to which follows which). Thus all groups are composed simultaneously, each beginning of a group being a possible continuation of each end of a group.”

Karlheinz Stockhausen, *How Time Passes by* (Stockhausen, 1957).

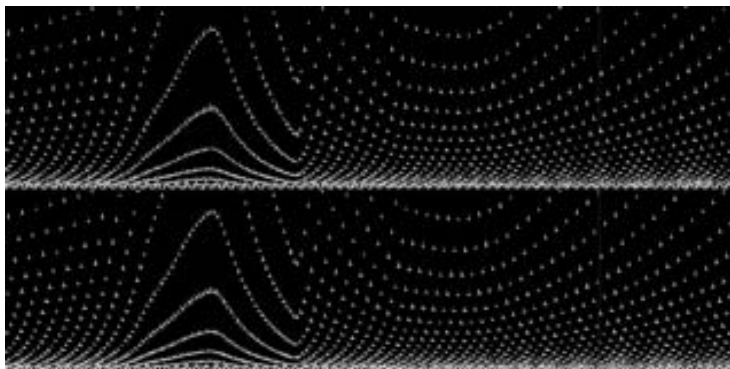


fig. 1.31 - Sonogram of the etude r136e. Positions in this simple 3d sonogram come from Rhinoceros 3d. I bend here the space using an attractor controlling phases. This is a simple (non-chaotic) attractors and changing from the projected initial attractors.

This game with various sets of spaces approaches something very close to differential equations. A differential equation is an equation that relates some function with its several derivatives; its changes within itself. Functions usually represent quantities, derivatives represent their rates of change, and the equation defines a relationship between the two. There is a frequency (so a periodicity), its acceleration, and the acceleration of acceleration etc. Frequency is not only a variation over time but also over all other parameters; it is multidimensional. Also, these are degrees of degrees of degrees of change with an infinite order

number. I could have composed using fractals where each order of derivation corresponds to a fractal dimension (1.4.2). This would have been interesting since one specific derivative can give an infinity of curves. But the object quickly becomes so complex, especially for the ear. Listeners have to use their memories between versions. They are already very busy integrating one single version by “fill” gaps from what they think they understand (2.2).

I believe the main interest using differential equations in my music are articulations and discontinuities. Inflections indeed allow segmentation and permutation both for the listener and the composer (1.4). I could call them pivot point. They can be located in any dimension number: lines, planes or spaces. I experimented furthermore with other discontinuous spaces; with lattices like tonnetz or more personal ones linked to the synthesis I was using (fig. 1.33).

These “sudden” changes permit folding and superposition as for origami or more traditional counterpoint techniques (McCormack, 2003). Issey Miyake is truly a master in this direction when he composes with unfolded textiles. In music, *Pli selon Pli* from Pierre Boulez or Milton Babbitt’s serial hexachords intensively use combination techniques. They both use thresholds, discontinuities, allowing inversions for various compositional parameters.

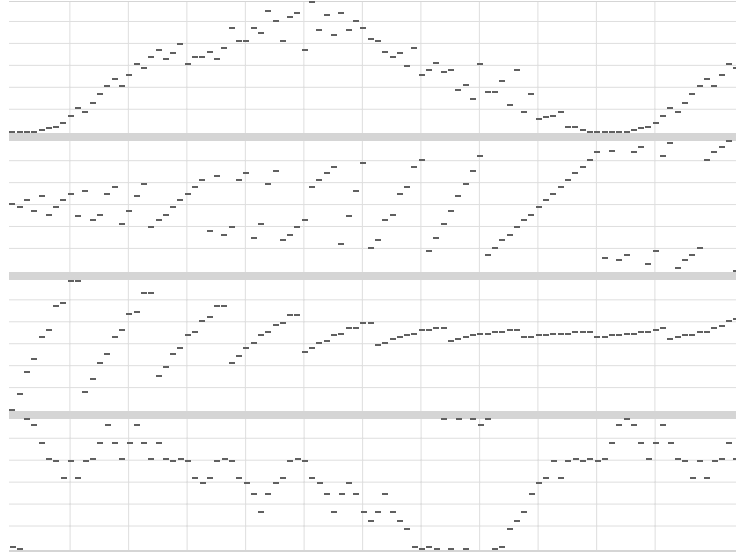


fig. 1.32 - AthenaCL LFOs used for *Forma*. They are based on discreet events.

```

1  sr = 44100
2  kr      = 441
3  nchnls = 1
4  odbfs = 1
5
6  pyinit
7  pyruni {{
8
9  from athenaCL.libATH.libPmtr import parameter
10 from athenaCL.libATH import athenaObj
11 ath = athenaObj.Interpreter()
12
13 f = parameter.factory(['c',0])
14
15 def truc(aa,bb,cc,dd,ee,ff,gg,kk):
16     global f
17
18     if gg > aa:
19         gg = 0.001
20         print("-----")
21         print("!!!!!! portamento longer than note duration !!!!!")
22         print("-----")
23
24     freq1 = bb
25     freq2 = dd
26     freq3 = ff
27     dur1 = aa * kk * cc * 0.01
28     dur2 = aa * kk * ee * 0.01
29     porta = gg * kk
30
31     b = dur1+porta
32     c = b+dur2
33     d = c+porta
34     e = aa
35
36     pp = 'bphc','e','s',(0,"+str(freq1)+",""+str(dur1)+",""+str(freq1)+",""+str(b)+",""+str(freq2)+",""+str(c)+",""+str(freq2)+
↵ ")+",""+str(d)+",""+str(freq3)+",""+str(e)+",""+str(freq3)+")"
37     f = eval("parameter.factory(['"+pp+"'])")
38
39     return 3.
40 }}
41
42 instr 1
43 ;table number
44 ifn = 1
45 adsp = 1
46 amul = 1
47
48 kPhaseEv line 0, p3, p3
49 iFq11 pycall1i "truc", p3,p7,p8,p9,p10,p11,p12,kr
50 kFq1 pycall1 "f", kPhaseEv
51
52 ;1 ms super fast envelope
53 aamp      transeg .0, 0.005, p4, 1, p3-0.001, p4*2-1, .0
54 ;spline jitter on amplitude
55 adsp      jspline p13, p14, p15
56 ;10ms of fade in to preserve attack
57 addsp linegr 0, 0.01, 0, 0.1, 1, 0, 1
58 ;nb of harmonics
59 kharmo line p5, p3, p6
60 ;generator
61 ;      asine buzz aamp*(addsp+1), afreq, kharmo, ifn
62 asine buzz aamp*(addsp+1), kFq1, kharmo, ifn
63 ;gain
64 ivol = p16
65
66 out asine * ivol
67 endin

```

fig. 1.33 - Extract of the CSound code used alongside AthenaCL. A python code is embed in order to communicate with the python that generated the score. This is taking care of the problem of polyphony by dynamically generating an opcode. The synthesis is based on a simple additive synthesis making an “acid” sound using a frequency sweep as attack.

My piece *Forma* uses inflections to articulate between the large amount of synthesis engine parameters and the large variety of gestures in the piece. The architect Frei Otto worked on gridshell structures which look for the minimal surface (Mennan, 2008; Songel, 2008). His meshes are very influential for *Forma* because they offer some naturalism close to actual material limitation (2.2.2). Forms are deducted from optimisation technique and eventually together join

beautifully and naturally. *Forma* apparently has no such physical limitation with gravity, weight or material quantities, but I replaced gravity by field attractors (fig. 1.31). Each section is designed with curves as a topological space deviated by point and line attractors and manually controlled splines for interpolation means.

I unfortunately did not find any truly interesting results yet. We will later see that it is a problem of perception; the form gets quickly too complex; changes are too slow or too fast to be understood by the ear. They then become continuously random or too basic and boring. The idea is still interesting for the concept itself and raises questions about complexity.



fig. 1.34 - Frank Gehry's Fondation Louis Vuitton in which *Forma* was premiered. The building's curves had an obvious influence.

1.3.3 Spatial computing

Periodicity, inflection and synchronicity of parameters are common concepts for both space and time. I consider them as spatial transformations that can be applied to sound spatialization or any other aspect of composition.

Entropy and spatial inference

Computational complexity theory considers not only whether a problem can be solved at all on a computer, but also how efficiently that problem can be solved. There is no problem in what interests me; but there is the question of existence. Existence is defined by the information it contains and how it is dealt with. I often want to call it a mechanism; the same as for watchmaking. Since I am dealing with composition of information, I can think about its complexity in a constructive mechanical way; not as a problem to remove, to solve.

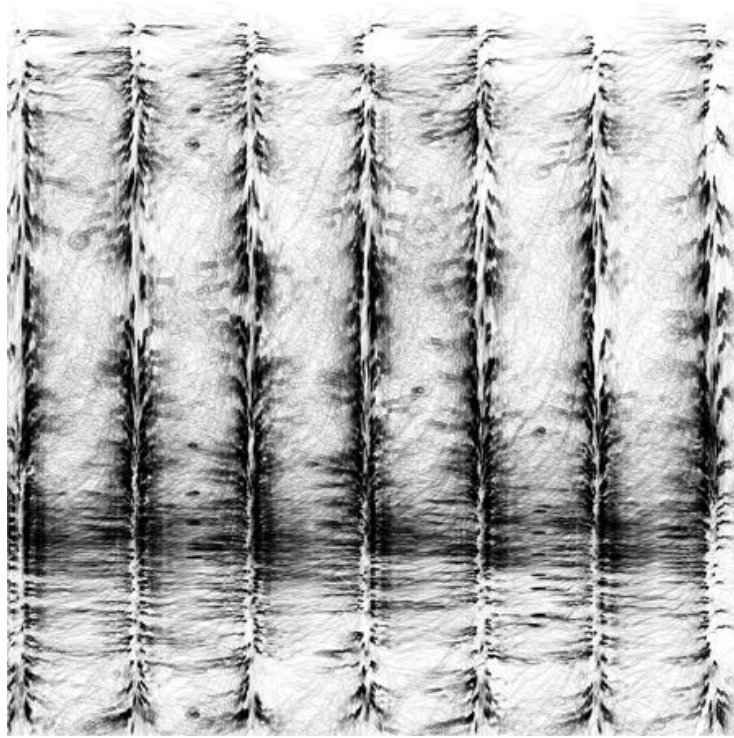


fig. 1.35 - Another print of *d/score/* in 2017. You can zoom in. When watched from a distance, it looks like the cover of Joy Division's *Unknown Pleasures*.

We have seen that computing machine was both a mirror, an extension and a displacement of our thought; a mechanism for transformation . In the program note for the February 1981 Ircam concert series *Le compositeur et l'ordinateur*, Pierre Boulez talks about the use of the computer as an opportunity to be forced to think about music and its mechanisms (Boulez et al., 1981):

“If there is one thing that computer use forces us to do, it is good to think about the very mechanisms of composition. It certainly does not have this unique power, since it also helps us to create the sound material in a perspective very different from that offered by the instrumental domain. In any circumstance of the invention, it forces us to a different route, to consider events from another angle - which has the consequence of disturbing our habits forged by both education and practice.”

Pierre Boulez, *Le compositeur et l'ordinateur*, *L'in(dé)fini et l'instant*.
(Boulez et al., 1981).

Complexity is a sense of how many alternating steps it takes to perform a

computation, and how much memory is required. The least possible case shows a minimum entropy (Shannon, 1948). Information is not compressible in that case. This means a generative composition with no involuntary aleatory would be the ultimate composition piece. But it would ultimately leave no space for interpretation (1.2.2). A piece would need transformations leading the audience towards the unknown in order to exist (Papadopoulos and Wiggins, 2000). This lead is a displacement and it needs some freedom to work.³⁰

Thought displacements going from premises to conclusions are important steps in scientific reasoning. But even “experimental” music does not imperatively need inference. It rather needs authenticity between different social actors (2.3.2). These are the meaningful coincidences that I describe earlier when working with mapping (1.2.3).

This authenticity would nonetheless sometimes come from trust towards scientific reasoning. My work does not consist of any true rational choices, but the authenticity I value the most still passes thru rational reasoning: imaginary inference spaces represented by Cartesian systems. Such representation naturally leads to an approach with continuous parameters: fig. 1.35. Discreet elements are embedded at another scale so it is then possible to use a coordinate system and analytic geometry for composing: spatial representation tools. Dmitri Tymoczko describes this fact using temperament for example:

(...) *“understanding of the discrete musical universe requires us to think in continuous terms. Even though we are ultimately concerned with equal-tempered music, we find that we can understand this music best when we consider the continuous space in which equal temperaments are embedded.”*

Dmitri Tymoczko, *A Geometry of Music*, (Tymoczko, 2011).

Topologic transformations

Toru Takemitsu, Maurice Ravel, or even Morton Feldman, with his asymmetric and unfocused music, were all looking for the most evident and just way to tight their multiple ideas together. This notion of justness in quantity is the essence of minimalism (Spive, 2008). It is also a way to set space by properly spacing its components (1.2.2). Toyo Ito said:

“I’ve long been interested in that notion of fluid space. I imagine it, not so much as an architectural space, as the space of Noh. Noh is a traditional performance art of Japan. I don’t know if you’ve ever seen Noh, but there is only an

³⁰I explore several tessellation techniques; essentially aperiodic rhythmic tiling.

abstract stage about 5.4 meters square in plan. Actors enter the stage by way of a bridge. Noh actors always move quite deliberately. It's almost like looking at a film in slow motion. The actors' movements are extremely slow and abstract but continuous. Through the dance of actors the abstract space changes into a fluid space. I've long wondered how such a continuous and continually moving space might be achieved in architecture. I've become convinced since meeting you that achieving that in architecture is possible."

Toyo Ito and Cecil Balmond, *Conversation: Cecil Balmond and Toyo Ito*
(Balmond and Ito, 2006).

Cecil Balmond and Toyo Ito together, talk about how a Noh actor moves from one instability to another. Spatial tension is maybe the understanding of both causes and consequences of movement (Balmond and Ito, 2006). I believe they are talking about potential derivatives of positions in parametric composition (1.3.2). They also underline the importance of controlling symmetry for potential energies.

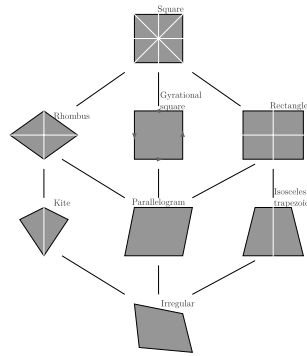


fig. 1.36 - Example of parallelogram transformation. Some of these quadrilaterals are rhomboid because they are deduced from spinning parallelograms. Those transformations are the result of displacements of vertices.

I until now only imagined transformations of single objects within a fixed space. It is possible to think of a relative movement between sets of immovable elements. Relation is only set between groups made of elementary elements. We encounter here set theory again. For instance, a transformation can also be applied to a set of fixed points making a square (fig. 1.36). One could go further by rather fixing coordinate systems, change spaces and get interesting manifolds.

I am sometimes still dealing with intervals, although I have no intention to create yet another tonality (fig. 1.37). These intervals I am after are applied to both signals and symbols. These intervals are simply representative steps of the concept. That representation is spatial for convenience because it can

be thought of as a simulation. It can be temporal or anything else. The final outcome is a *music by number* (Assayag, 2005).³¹

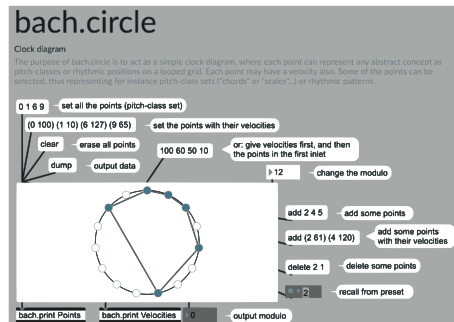


fig. 1.37 - Classic example of circle used in the Max Bach library written by Andrea Agostini and Daniele Ghisi (Agostini and Ghisi, 2012). This diagram easily allows us to appreciate periodicity. It has proved to be very convenient for pitch-classes or rhythms. It is the same tool because pitch is the integration of rhythm. One can hear a pitch when a rhythm is played fast.

Exemple of envelope spatialization



fig. 1.38 - Thibault Vinçon as Steve Jobs in *Steve V*, 2014

Sound spatialization has no direct link with spatial computing described earlier (1.3.3). I can however, chose to conceptually connect them together and materialize my ideas into an architectural space (2.2.2). It is the opportunity to experiment with direct connections between conceptual rhythms and curves applied to spatialization. Envelope spatialization created an initial transparency,

³¹I have a special thought for ICC, Tokyo, with their talks about *Sculpting by numbers* (Rivers et al., 2012).

fig. 1.41 - Spatenv is the name of the tool I have programmed for envelope spatialization. It makes use of a variety of Bezier curve generators.

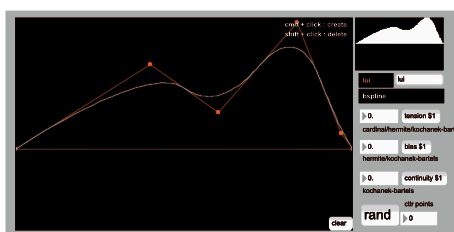


fig. 1.40 - Spatenv is the name of the tool I have programmed for envelope spatialization. I build a set of envelopes using a variety of Bezier curve generators.

I then used envelope spatialization: a unique signal is sent to a large amount of speakers with all their gain down. Those gains are then raised individually in a various manner. The opening is controlled by a rhythmic engine using LFOs, discrete envelopes (spline interpolations or Bezier envelopes) (1.41). Depending on the envelope and the overlap, it is possible to pass from a traditional panning to something perceived more like a spatial granular synthesis. When periods are faster than the ear discrimination, the incoming sound is modulated thus creating electric or acoustic phasing effects or ring modulation. This system gets very efficient for articulations and does not require any sweet-spot. In my pieces, I consider the position of the audience does not matter since they should hear

a displacement rather a placement. The engine I developed is called Spatenv. I often use both for interpreting and composing. This engine both uses the *Ircam Spatialisateur*, my rhythmic library *Jtol* and a system for interpolating dictionaries of b-spline (1.4.2) (Jot and Warusfel, 1995).

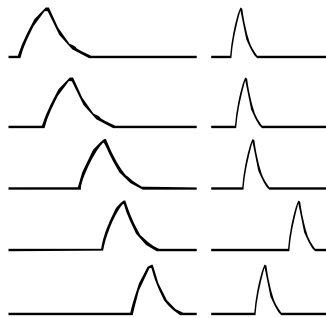


fig. 1.41 - The set of envelopes made Bezier curves are chosen then played rythmically, with *Jtol*, and send to a defined sequence of speakers. The figure here shows a change of factorization for each speaker, controlling the length of envelopes thus the overlap for a possible panning (cos curve) or something more pointillist (distorted gauss-like curve).

This technique started with Brice Pauset's *Perspectivæ Sintagma I & II*, *Symphonie III* and *Exercices du Silence* for which I did the electronics. Emmanuel Nunes also intensively used it for instance in his excellent *Lichtung I, II & III* series. Spatenv is now definitely part of my composition system and has eventually become more than just a tool. It is used for most sound projections and its processes are also part of the composition. The effectiveness of Spatenv does not only concern the auditory perception, it is one materialization that the audience understands physically.



fig. 1.42 - Michael Slattery being Steve Jobs' cancer. Shadows in the background are singing Apple men.

1.3.4 Choice of generative systems

We have previously seen I have made a personal approach that fits my needs. I am after autonomous evolution of patterns and would then rather use iterative, computational, processes such as cellular automata.

From generalization to specific choices

A generative system is a technique that builds information or material in an autonomous way, without human intervention. The question of autonomy is relative because it totally depends on where, in the creative process, control is done, or whether it should just exist. This existential question does not totally define what a generative piece is but its consequence nevertheless defines its outcome. Such system is often automatic and allows multiple versions following the same initial concept. The definition of how the automation should be performed is often detailed by algorithms in which there exists a full scale of arbitration between randomness and predictability, both for the outcome and the making.

The necessity for formalization is then questioned. My experience, alongside the tools I am offered, revealed to me the necessity to choose the right balance between generalization and specification for a generative system.

Generative systems are technologies with the overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences. When generative systems provide a common platform, changes may occur in varying layers (physical, network, application, content) and provide a means through which different firms and individuals may cooperate indirectly and contribute to innovation.

Generative art refers to art that in whole or in part has been created with the use of an autonomous system. An autonomous system in this context is generally one that is non-human and can independently determine features of an artwork that would otherwise require decisions made directly by the artist. In some cases the human creator may claim that the generative system represents their own artistic idea, and in others that the system takes on the role of the creator.

An absolute generalization or total randomness, from a certain point of view only, would totally discredit the piece. I am dealing with a simple but true fact, the art of change, *veränderungsgrad* as Karlheinz Stockhausen would call it (Stockhausen et al., 1955). This option is primary in my choice for a generative system (1.3.3).

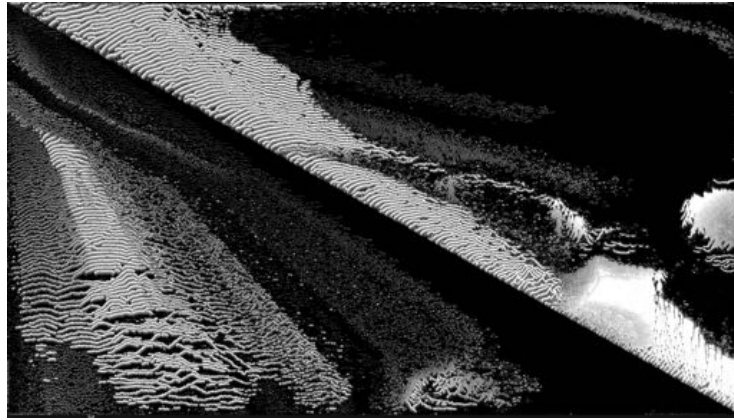


fig. 1.43 - Snapshot of the video *Proxima b1* using a personal derivative of cellular automata. It has a strong taste of computer arts from the 1980s.

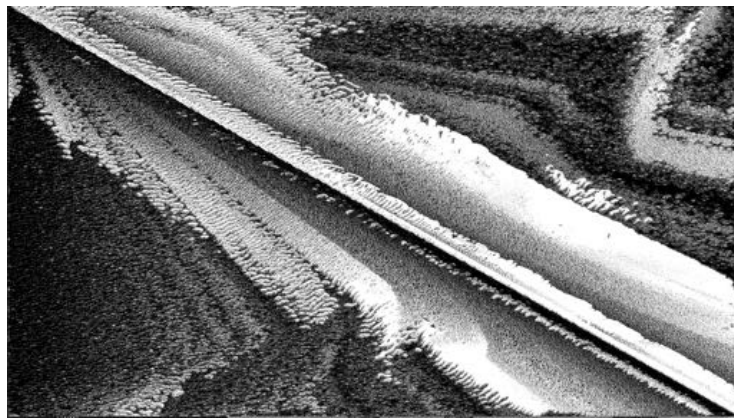


fig. 1.44 - Another snapshot of the video *Proxima b1* a few frames later. The piece normally uses three 4k screens in parallel; I use GPU power and Max Jitter *jit.gen* to compute all the points.

Computational and iterative algorithm as an evolutionary generative system

The piece *Proxima Centauri b*, created in Taipei in December 2016 for the Taipei National Museum of Fine Arts is a good example (fig. 1.43 & 1.44). It is inspired by the inner and surreal contemplative rhythms of Weiner Herzog's *Aguirre, the Wrath of God*. The piece simply uses a Conway's game of life and reaction-diffusion to create long and quick evolutions. This emerging spatial and sonic composition initially come from the concept of cellular automata (Zuse, 1969; Penrose et al., 2013). Patterns come from a particular grammar at microscopic scales and propagates into macroscopic ones. The current system spreads into two different times: the sequence of frames and the spatial evolution of pixels

within frames. This creates an artificial universe to be listened and watched:

“This view is centered on the idea that physical phenomena are best understood in terms of digital information processing concepts. In its most extreme forms, it suggests that the universe is discrete, deterministic, finite, and evolves by simple computing rules. The central conceptual equation for this line of thought is:

complexity in nature = emergence in computation.”

Roger Penrose, Tommaso Bolognesi, *A Computable Universe*,
(Penrose et al., 2013).

As for *Fomalhaut* Γ , this work is intended to be seen as a framed painting watched from a wide angle. But it is also intended to be read as close as possible by looking at individual groups of pixels (1.2.3). The image must be presented onto several relatively small screens with the highest possible pixel density. The best version would again be with e-paper when the technology will be available. Each screen starts with the same setup; the same initial pattern and a set of rules. Even after many iterations, they would get the same complex outcome until a point of randomness decided by one rule would radically change the evolution for each single screen.³² The system is not an actual game of life because I use additional time-based rules using delays and operations between layers. The strong aspect of recursion brings aliveness alongside its spatial and timed visual rhythm I am after. The sonic part strictly follows what is seen. One can clearly hear recurrent swung micro-loops. The sonic generation is then entirely build by the same cellular automata as the visual. I however had sometimes to select only one layer for clarity.

I also explored systems based on transformations from one state to another using a great deal of operators. Such procedures involve a series of agents conducted in a certain order. Form comes from information propagating inside a composition space. This clearly involves a synergy between iterations and computation. The model of computation is based on the repetition of a large amount of elementary processes. Computational design is here deeply involved because they provide composition tools which better suit conceptual and time-based approach rather a purely musical one.

Finite or parametric

Connections between continuous evolution and discrete states are done by the public himself, at the moment of interpretation (1.4.2). But the choice be-

³²Aggregation is essential. I believe it models how my ideas propagates from random initial sparks to form (1.3.2).

tween finite states and a more parametric approach depends on the needs of the composition. Everything needing discrete elements like rhythms will need a finite approach. A continuous approach will more be dedicated for articulations and trajectories (1.3.2). It gets more subtle when actually connecting both approaches together within a same composition process using various integrals. This is the case with my piece β *Pictoris f*. Depending on my needs, I use both approaches that sometimes get very close one form another.

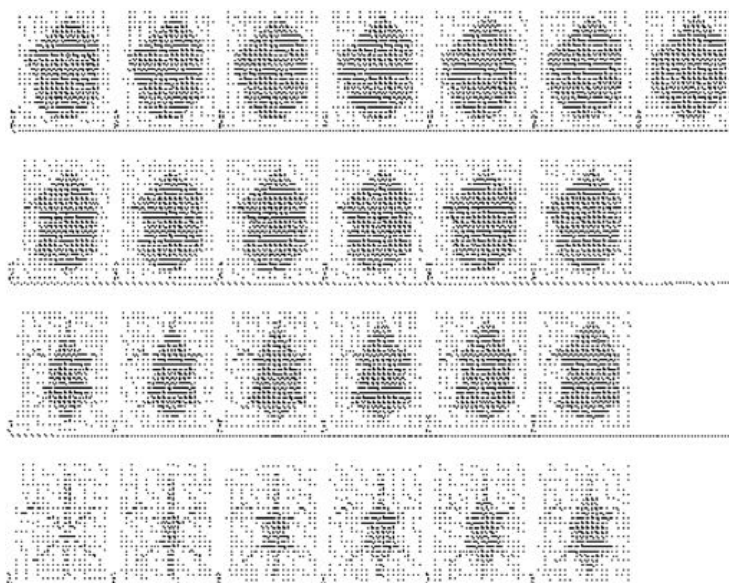


fig. 1.45 - We can see in this future piece, certainly called *Trappist-1*, that patterns are lying onto a quantum field. This piece has no intention of being linked with quantum mechanics; just inspiration.

1.3.5 Transition

My core musical question correlates the relations and differences between classes of moments and positions. The simplest representation becomes an object for which each dimension corresponds to one composition parameter. This multi-dimensional body can be represented in a continuous parametric way from a specific scale. Mapping choices with synthesis parameters is primary, but scale sometimes defines continuity and allows iterative positioning resulting in the construction of patterns and forms. Computation with discrete elements nevertheless generates complex displacements that can easily be arduous to comprehend; although the concept can be beautiful, its artistic outcome often remains difficult. I adopted a perceptive approach where correlation between elements, giving a notion of time, is achieved using interference: moirés. I then focus on layers of waves and generate contrapuntal rhythmic layers. This strong deci-

sion implies a particular workflow and a way to deal with information from its generation to the manner in which it can be received.

1.4 Nano & quantic composition

Curves described in the previous section evolve within an abstract multi-dimensional space. One coordinate simply controls one composition dimension. I will here describe my choices for data representation, its spatial transformations and consequences for composition from a scalar point of view. We will first see that the question of continuity defines whether the approach is finite or parametric; if I will work more with waves or particles ; a quantic-composition (1.4.1). This raises the importance of scale, 1.4.2, and how elements spread from an infinitesimal scale to a macroscopic scale; a nano-composition (1.4.3).

1.4.1 Wave and particle for rhythm

My computer music is only played by machines and explores the limits of perception: discrete vs continuous from the perceptual and conceptual points of view.

The question of continuity



fig. 1.46 - *Les Quatre Temps Cardinaux* is a 55 minutes piece for orchestra, live electronics, voice and video. I did the electronic part, the voice acting and the video. Patterns in the sound and video are microscopic and show moving moirés in three chosen projection axes: a non-euclidean plane and non-linear time (Dalrymple Henderson, 2013). Complexity is again here minimal from far away and maximal when watched from a close distance.

Working with evolution using both waves and particles is powerful and the wave-particle duality in physics is a suitable source of inspiration. The idea of quantized elements further determining an entire piece is appealing. This

means a composition system can use particle systems where iterations define the growth of the piece (1.3.4) (Thompson, 1942). There is undoubtedly an analogy with phonons and vibration propagation (Wolfe, 1998). A phonon is a sound particle inside a physical middle. For me it remains an approach and a tool for a thought experiment.

Duality for wave and particle is clearly proven in quantum mechanics. I have no intention to infer with universal and absolute legislation. I would rather dare to play with a connection between the Heisenberg principle and a series of pieces. The Heisenberg principle asserts there is a limit of precision in the position, and momentum, of a particle for instance. This means one does not know where a particle is; so there is an uncertainty for identity or a several positions at the same time. The fact my pieces are generative allows the making of an infinity parallel versions at anytime. Which one is the actual piece ? When was it created ?

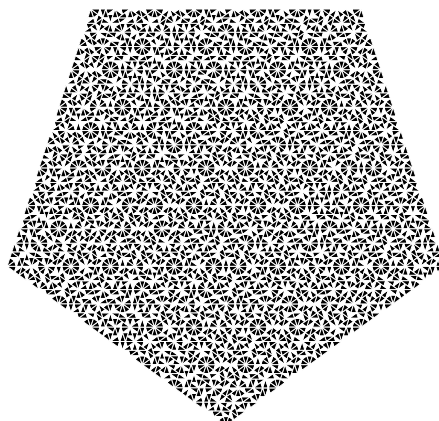


fig. 1.47 - Non-periodic Penrose tiling generated by an aperiodic set of prototiles

Poly-rhythms and sense of pulsation We have seen in a previous section I was considering parallel times from the reader, the audience and multiple composer's parameters (1.2.1, 1.4.1). These multiple times interweave together and synchronicity becomes an important game (1.2.3).

My interest in linking continuity with discontinuity does not allow me using traditional counterpoint which deals with discontinuous elements. I could instead have chosen any epigenetic approach and for example worked with the nucleotides of DNA (Mihalic, 2001). I could also have used Roger Penrose's tiling and his brilliant graphical notation (fig. 1.47) (Penrose, 1972).

It appeared simple to make a connection between discontinuity and continuity by zooming out any process or increasing tempi until elements merge together

into groups. The resulting interlacing creates interference. It is a variation of symmetry; a *moiré* effect (1.4.1) (Don et al., 2010).

Simplest possible rhythmic elements have proved to me being the most efficient for *moiré* effects. Especially for sonic events where the real-time factor and memory are primary constraints. Such poly-rhythms have strong links with the potential energies and focus I describe earlier (1.3.3). The accent in a pattern happens where energy is the strongest. With interference a node is the place where energy is the strongest and can be considered as an apparent pulsation. The latter is all about specific positioning. Elements within the interference variations are more or less stable, more or less distant from nodes. This raises again the notion of stability and amounts with minimalism. Vladimir Nabokov talks about it in terms of sensational beats:

“Maybe the only thing that hints at a sense of Time is rhythm; not the recurrent beats of the rhythm but the gaps between two such beats, the gray gap between black beats: The Tender Interval...”

Vladimir Nabokov, *Ada, or Ardor: A Family Chronicle* (Nabokov, 1969).

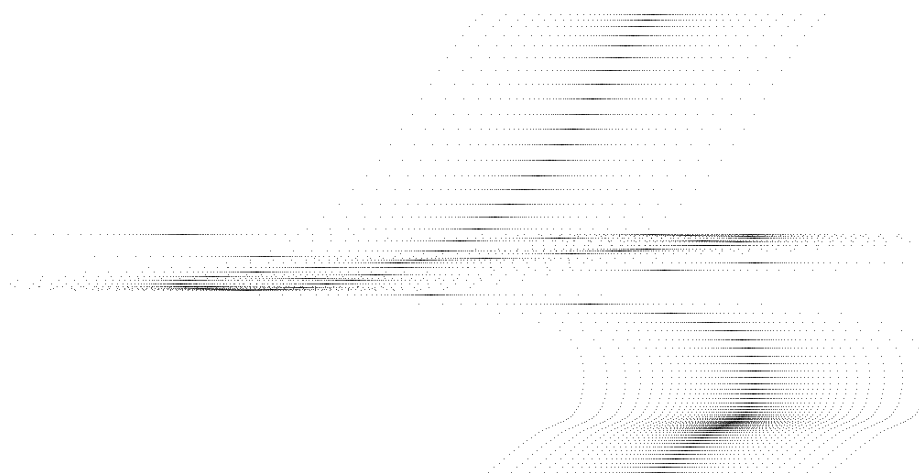


fig. 1.48 - One of the infinite scores for *The Nothing, Seeking Answers: Indivisible Streams*. This picture is vectored and directly generated from Max.

Conception as a whole emergent entity without separate instruments

Ueno Masaaki, Frank Bretschneider or Steve Reich use poly-rhythms in a personal way with a strong sense of pulsation. They consider time as either continuous or discrete and succeed in blurring the distinction for the listener. They freely pass from symbol to signal. They are nevertheless no real continuum and

they keep the traditional paradigm of stem.

Maybe only musics like the one of Kasper T Toeplitz, Zbigniew Karkowski or Sunn O))) are composed of a one-block process, one object, a texture (Karkowski, 2008). Georg Friedrich Haas, Peter Ablinger and also spectral music composers such as Joshua Fineberg make use of specific orchestration to link the symbolic and the signal information together in instrumental pieces (Fineberg, 2000). I think like Jörn Loviscach who proposes a *Spectral Synthesis of Rhythms* in which musical elements are all linked together and have no instruments or tracks (Loviscach, 2011). It is rather thought as a whole, a uniform sculpture made of the same material. Inner motion has to emerge from something else than a traditional “orchestration” (1.4.2).

Rasterized and vectorized information In his *Pedagogical Sketchbook*, Paul Klee enumerates all the techniques he can formally explain (Klee, 1953). Sibyl Moholy-Nagy writes the introduction:

“The Pedagogical Sketchbook is the abstract of Paul Klee’s inductive vision. In it the natural object is not merely rendered two-dimensionally, it becomes “räumlich,” related to physical and intellectual space concepts, through four main approaches that form the four divisions of the Sketchbook:

- *Proportionate line and structure,*
- *Dimension and balance,*
- *Gravitational curve,*
- *Kinetic and chromatic energy.”*

Introduction by Sibyl Moholy-Nagy, *Pedagogical Sketchbook* (Klee, 1953).

Also *Paragraphs on Conceptual Art* from Sol LeWitt is less technical and proposes 35 social facts about conceptual art (Lewitt, 1967):

“These paragraphs are not intended as categorical imperatives, but the ideas stated are as close as possible to my thinking at this time.

- *Conceptual artists are mystics rather than rationalists. They leap to conclusions that logic cannot reach,*
- *Rational judgments repeat rational judgments,*
- *Irrational judgments lead to new experience,*
- *Formal art is essentially rational.*

Sol LeWitt, *Paragraphs on Conceptual Art* (Lewitt, 1967).

These two catalogs categorize their techniques and try to find general concepts from them. They are not a generalization of the art pieces but they

nevertheless expose a consistency across the artwork. This shows up choices made by the artist (1.3.4).

These books make categories and analyse the topology of those categories. The later can both be purely technical and artistic. They can also be symbols and signals at the same time depending on the need. A back and forth between both types are done with analysis techniques that cluster groups together. One could for instance build classes using sound descriptors and clustering.

Symbol processing initially needs to define what are the symbols it will process. Clustered symbols would come from segmented signals becoming vectors. This approach is widely used for data compression (1.2.3).

Raster signal comes from sampled information. Then vectors allow the interpolation between segments, bending and other topological transformations and spatial computation described earlier and used for parametric composition (1.3.3). It is here a new opened window to the difference between discrete to continuous I am writing about here: 1.4.2.



fig. 1.49 - Snapshot of *Les Quatre Temps Cardinaux*, 2015. Zoom in to see interference.

But raster also allows interesting artistic techniques with a strong characteristic of segmentation and everything that comes with it (phasing, interferences, gradients etc.) (fig. 1.49). For instance, Otto Beckmann is a pioneer of computer video art who was not only working on abstract pieces.³³ He also was recreating his nature with the distortion of images or generated forms against pictures. His style is strongly connected with the raster effect provided by cathodic screens.

Works from Alva Noto, Jesse Osborne-Lanthier or the excellent Grischka Lichtenberger are adequate examples too. Their simplistic sonic glitch elements

³³See the work and writings from Frieder Nake, Vera Molnar and Manfred Mohr (Kompetenzzentrum Digitale Kunst, DAM gallery, ZKM, Bitforms).

are composed as very sharp segments. The form of their piece does the smoothing.

Propagation Some pieces make use of propagation in a quantized medium computed by discrete processes; their process spreads. This is the case with *Proxima b1* in which propagation itself generates audio and visual patterns. The inspiration is here again quantic: my work is altered by the observation of its context.³⁴

Other artists using similar developmental methodologies. Light works of Otto Piene or Olafur Eliason are adequate examples too. Also Peter Beyls with his work on artificial life evolution.

I notice again that, for all of them included my piece, simplicity is primary for a better understanding of propagation: Ø (aka Mika Vainio) with *Metri* for instance, Richie Hawtin, with the *Concept 1* LPs collection alongside the work of Robert Hood in the 1990s or CoH aka Ivan Pavlov in the 2010s. The intensive use of periodic LFOs and step sequencers is one consequence of this direction. The stylistic consequences are legion with Krautrock which psychically explores boundaries between drone and rhythm. The best example for me is *Speedy Achmed (Verhaltensanweisung)* from Eckhart Seesselberg and Wolf Seesselberg released in 1973.



fig. 1.50 - Another snapshot from *Les Quatre Temps Cardinaux*. A specific grain noise modeled from a specific film camera is here interfered with itself. The background comes from pictures of iced horizontal landscapes interpolating one after the other in very slow motion thus giving two layers with totally different speeds.

Pseudo-periodicity and precedence effect Practically, I see interference as the consequence of a superposition and de-correlation between two slightly

³⁴I am making a reference of Erwin Schrödinger.

delayed signals (1.4.2). Precedence effect (or Haas effect) is then important for the superposition to generate anything interesting. Horacio Vaggione and Curtis Roads works show this (Vaggione, 1996; Roads, 2005):

“Retrospectively, I would say that I found a medium that was challenging our notions of causality, divisibility, simultaneity, interaction, energy, and so on.”

“Once you are sensitive to a multi-scale approach to composition, you don’t see the note as an atomic entity - a primitive building block - anymore, but rather as a layered object containing many interacting time scales.”

Oswaldo Budon & Horacio Vaggione, *Composing with Objects, Networks, and Time Scales: an Interview with Horacio Vaggione* (Budon, 2000).

Depending on tempo and its periodicity, events reproduced faster than the ear provide an impression of pitch. This what the *yin* pitch detection and *psola* synthesis use (de Cheveigne, 2002). In 2010s vocabulary, he describes the fuzziness and integration of gabor wavelet as sound grains into timbral texture. Such properties do not only concern time flow. They are the coupling between every musical element.



fig. 1.51 - *Arealague* 2016’s collection using transparent grooved screens and patterned clothes for a moiré effect. I felt I had no choice but to concentrate the music on phases and rhythms.

I was asked to compose the music for one of the 2016’s *Arealague* fashion

show. The rather modernist team of creators used a concept that perfectly fitted my research. As a consequence the public could watch and hear “techno” moirés; interference between people and clothes, all in grey (fig. 1.51). Two ideas were proposed. The use of a striped screen surrounding the stage, a layer of striped transparent clothe on top of the actual dresses. The effect was rather different and the second solution was used at the very end of the performance to reveal the actual clothes made of grey squared patterns. Everything was squared; four rear speakers behind the audience were used to sometimes reflect first reflections coming from four speakers on the squared stage. The piece is a rhythmic 15 minute piece following the steps of the models and changing its movement for every change of style in the fashion design. Sounds consist of phases of sharp superposed noise bursts until the screen is leveled and leaves an opened sight to the actual clothes. At this moment, the same insisting pattern is reverberated to the rear speakers thus giving breathing and revelation for the audience.

Random walk and use of gradient noise

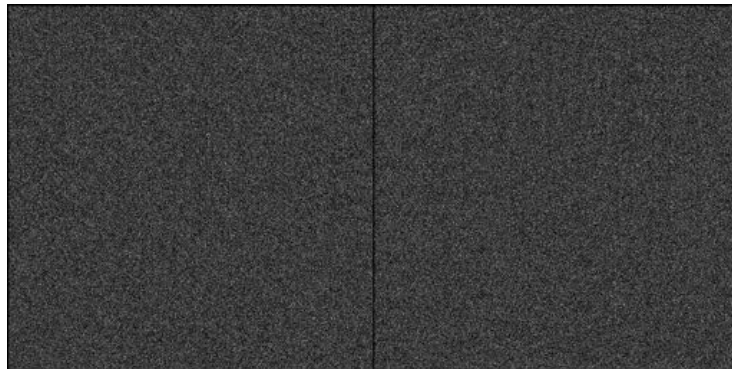


fig. 1.52 - The visual piece shown here invites visitors to internally explore evolution. From far, the piece is as one block, from a closer point of view, it seems structured. The second print next to it invites for a comparison. It is a random distribution and this does not matter since the importance is in the visitors’ interpretation. Entropy is almost maximum so it is very hard to computationally reduce it.

We have seen earlier, I was mostly thinking about ratios and differences between trajectories of parameters. Functions describe the evolution in all available composition dimensions. The link between all synchronized functions can also be another function. This complex system would ultimately represent the piece in its entirety or, maybe a description of it giving a rough idea of the style (Stiny and Gips, 1978). It is difficult to deal with such a large amount of dimensions and parameters. I can build a meta-system which would help me compose with layers of importance, for instance. But I am interested in autonomous

generative music. I then decided to use the most autonomous generator in the deepest levels of my compositions.

I image this initial state as the initial spark from which an aggregation assembly technique will hook later processes (1.4.2). This idea starts from random agents, but eventually converges, auto-synchronizes, towards emerging clustered patterns (Halbwachs, 1993). Consecutive trajectories are then all linked in all directions. There is a coherence, but blind. One of the most obvious random method is the use of Perlin noise.

The best example of that idea is the installation piece *The Nothing, Seeking Answers: Indivisible Streams*. This was part of a collaboration with Elías Merino, Francisco López, Daniel Del Río and Rian Treanor. It was premiered at Cafe Otto in London in July 2016. I used the same of moiré methods and synthesis as for *Arealague* (1.4.1). But this time, I decided to use deterministic, symmetric canon structures in the same way James Tenney or Conlon Nan-carrow would do. James Tenney's spectral canons are time shifts and become sound thanks to its fast tempo or deepness. I rather decided to control shifting using a Perlin noise that would linearly deform the canon structure. This provides more variety and avoids recognizable patterns of such direct canons. I could have also used a deterministic approach like Dan Tudor Vuza's for instance (Mazzola, 2002). But I found using obvious symmetry artistically easier to work with (fig. 1.53).

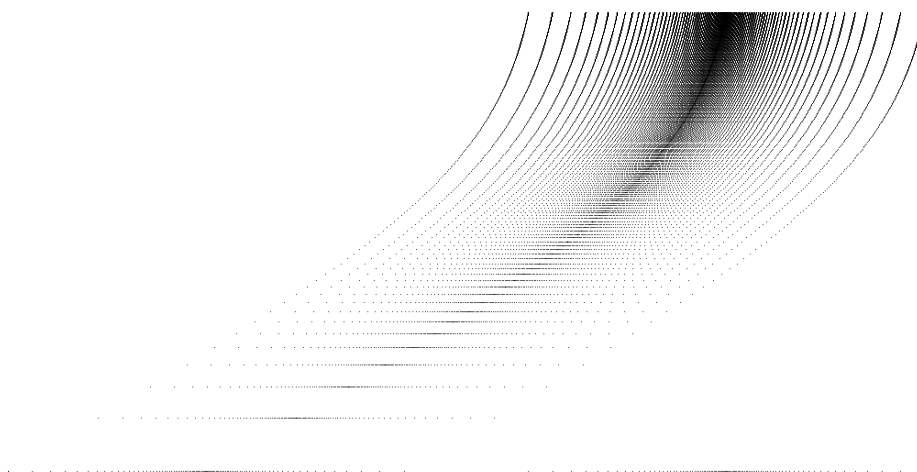


fig. 1.53 - Another one score for *The Nothing, Seeking Answers: Indivisible Streams*.

1.4.2 Scale relativity

Wave and particle approaches lead to composing from the nano-scale, the infinitesimal. Discreet elements are built at this scale. I use Jtol, a tree represen-

tation that fits with a pseudo-fractal conception of music.

Tree representation and graphs

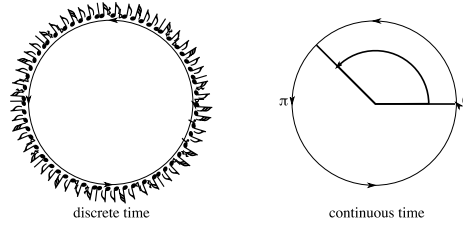


fig. 1.54 - The duration of a bar can for instance be represented by the circumference of a circle.

Quantization If I want to get audio and visual interference between layers, I simply need to allow a comparison. I then need to superpose at least two elements. One can be complex patterns while the second one a simple grid.

Instead of using an actual grid, it is also possible to use a non-periodic segmentation of the input stream. This segmentation and the grouping of the resulting structure can determine a meter (Nouno, 2008). Such cyclic properties permit the use of complex numbers and complex plane. This could be a “complex space” for the multiple parallel time representations described earlier (1.2.3). Each bar is set in a circle or a sphere or a n-sphere when using more dimensions.³⁵ Rotation and modulus are the processes employed. A 360 degree rotation is the entire length of one bar. This allows having fixed durations for further superposition of layers (fig. 1.54).

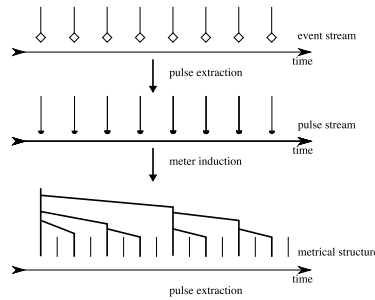


fig. 1.55 - Meter induction.

Using such a periodic representation is far from new, but is still very useful. There is always a method for returning to an initial starting point after a full

³⁵It also be a spiral or any circular helicoid if we decide to only consider one cyclic dimension while others are linear.

rotation: by definition, the length of a bar cannot be longer than the circle that represents it. Everything that happens inside the circle is within the bar.

Complex analysis is an equivalent for cyclic, or rhythmic related, parametric techniques (1.3.2). It allows a continuous analysis of information to become discreet. It is also an easy tool for the trigonometric rational quantization of pseudo-periodic patterns (fig. 1.55).

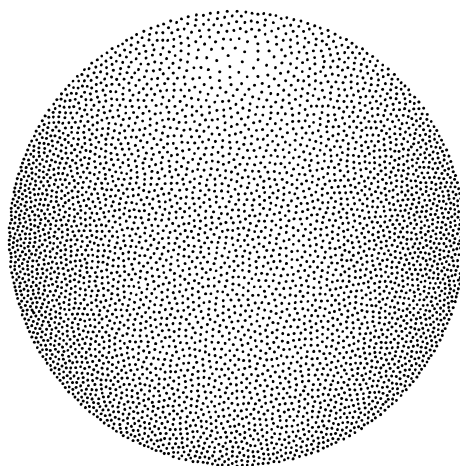


fig. 1.56 - Simple halftone pattern with a little bit of randomness. The eye sees patterns from dithering. It also integrates densities together and interpret an enlightened sphere.

Half-toning and gradation Half-tone and gradation rhythms are often represented with rationals partly because they can easily be apprehended by humans who need to count time points in order to perceive a flow (fig. 1.56). This is not always the case for machines, but it is essential for a (human) audience who also requires clustering and comparisons between groups to determine rhythms and have a sense of time.

Pulsation, as I conceive it, is where peaks of energies are located within a specific region; the loudest or the highest density. Half-tone is a good approach for determining these regions. It is a useful method for reducing data, while keeping the necessary gradations (Warnock, 1969).³⁶

For instance, the band Autechre is recognized for highlighting intricate onsets from a pulse stream (fig. 1.55). Some of their notable tracks on the *Confield* or *Elseq* are based on random patterns from which a focus emerges, and then changes, over time. Also, the percussive sounds and pulsations often lead the listener into a gradation analysis of discreet organization to complex ones.

Karl Otto Götz's computer pieces in the 1980's use a similar idea. Reproductions of large amounts of infinitesimal and complex elements form groups

³⁶Using Bitmaps is good for getting a continuum between wave and particle (1.4.1).

and patterns (DeWitt, 2000). Using infinitesimal elements notions of scale arise as Iannis Xenakis describes in *Musiques Formelles* (Xenakis, 1992):

“All sound is an integration of grains, of elementary sonic particles, of sonic quanta. Each of these elementary grains has a threefold nature: duration, frequency, and intensity.¹ All sound, even all continuous sonic variation, is conceived as an assemblage of a large number of elementary grains adequately disposed in time. So every sonic complex can be analysed as a series of pure sinusoidal sounds even if the variations of these sinusoidal sounds are infinitely close, short, and complex.”

Iannis Xenakis, *Formalized music* (Xenakis, 1992).

Jtol rhythmic tree library I needed to develop a tool for quantizing and generating rhythmic patterns that maintained the segmentation of pseudo-cyclic times using rationals; a musical necessity (1.4.2, fig. 1.57). The most obvious representations available were nested multiple-scales; lists of lists processed by grammar as Aristid Lindenmayer used: a tree structure representation (Prusinkiewicz and Lindenmayer, 1990).

Brian Ferneyhough developed a similar tree structure system. This was ported and extended on PWGL and *om:tree* in Open Music software. *ENP notation* uses the same idea with a more generalized front-end. It allows any parameters to be attached to branches.

These tools are all designed for readable music. The system I built is more dedicated to computer generated patterns. It does not take slurs and beaming into account, but rather allows vector calculus, which is not directly readable by humans and more adapted for processing.

I developed in Max the Jtol with the help of JT Rinker.³⁷ It consists of a large collection of tools I started a year before the PhD period and that is still growing. This library is specifically dedicated to real-time processing and can be applied to architectural design, music, dance: in effect, everything requiring constructed evolutionary systems.

The main concept consists of thinking in terms of ratios at each tree level. Each ratio before a new parenthesis level is the total duration of what is inside the parenthesis. For instance, a simple tuplets would be expressed in the following way:

³⁷Jtol and examples are available on Github: <https://github.com/opasquetdotfr/Jtol>.

$$\begin{aligned}
& (1 (1 1 1)) \\
\Rightarrow & (1/3 \ 1/3 \ 1/3) \\
\Rightarrow & (0.333 \ 0.333 \ 0.333) \ \Sigma = 1
\end{aligned}$$

Another example:

$$\begin{aligned}
& (3 \ 1 (2 \ 1 (1 \ 1 \ 1))) \\
\Rightarrow & (3/4 \ 1/6 \ 1/36 \ 1/36 \ 1/36) \\
\Rightarrow & (0.75 \ 0.166667 \ 0.027778 \ 0.027778 \ 0.027778) \ \Sigma = 1
\end{aligned}$$

Here are two examples of the long list of available processes. They show the interest for using a tree structure data representation.

Jtol.bach.reduce reduces depth of trees (fig. 1.57). An initial rather complex tree is being reduced level after level until only one remains. Both used in a polyphonic or sequential mode it enables the listener to recognize the deepest level. One can think of nested rhythmic subjects still consistent in the case of strong rubato for instance. Passing from level 4 to level 1 adds ornamentation layers to previous branches (1.4.2).

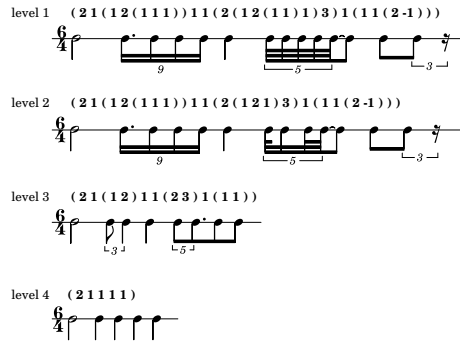


fig. 1.57 - *Jtol.bach.reduce* is part of my Jtol library.

The patch shown in the figure fig. 1.58 is called *Jtol.bach.humanize*. It adds a rational jitter and outputs a nested list that can be used together with other processes. The library has a rich collection of algorithms for quantification, noise, permutations, sieves, swing, tree reduction, repeaters etc. The majority of available processes can be applied to specific tree levels without affecting other parts of the tree. It applies durational transitions within the same rhythmic properties.

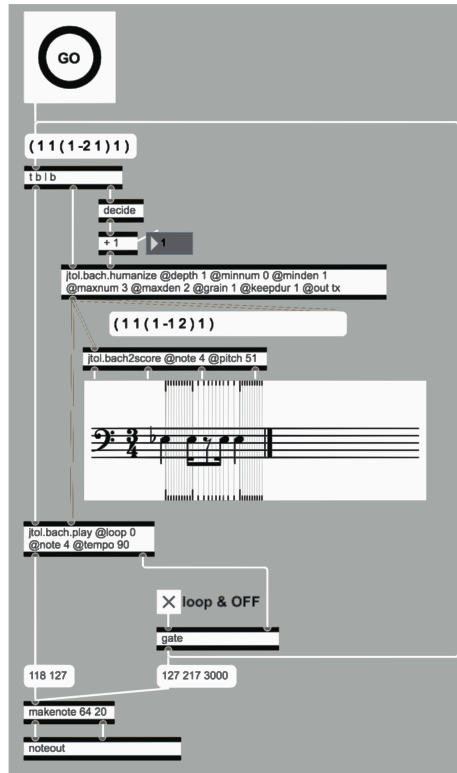


fig. 1.58 - *Jtol.bach.humanize* is part of the Jtol library. This tool allows rhythm processing using a tree structure representation. *Jtol.bach.humanize* adds rational randomness and outputs the result also in the nested list format explained above; allowing a very deep complexity.

Ornamentation of meshes My piece β *Pictoris c* demonstrates these Jtol's features in an interesting way. This piece was composed for 26 speakers and commissioned by the Moscow Digital Art Festival in 2015. The piece is part of a work in progress which will eventually become a series (1.2.3). I used the Jtol library to generate rhythms and apply envelope spatialization similarly to β *Pictoris b* (1.3.3).

Tree branches hooked to other ones give a very specific aesthetic characteristic by considering sub-branches as ornaments. Depth of interconnected layers generate a noisy kind of baroque (1.2.2); maybe rococo (Spuybroek, 2005). At least, a poetic *artificial Nature*.

The topology of the multi-dimension rhythmic grid is a mesh. This skeleton can be plotted with Delaunay triangulation (McLean et al., 2007). This structural relation approach is very similar to methods used for fabrication structures (1.3.2). The architect Lars Spuybroek does not think in terms of music, but the construction of his forms is also based on multiple scales of ornaments. In his book *The Atter of Ornament*, he talks, via John Ruskin's expressionism, about the acts of making, building, occurring specifically in the transfer from abstract

to concrete (Spuybroek, 2012). Ornamentation could sometimes be considered as accidental or dirty elements, that are part of Nature:

“Ruskin shows time after time in Modern Painters that there are only gradations and variations. That is, there are gradations not only of hue and brightness but of dimensions themselves. Texture occurs when enough lines produce a surface, as when fibers nest and tangle, or when surfaces start to produce lines, like sharp waves on water or cracks in drying mud. It seems that only the in-between of line and surface truly exists, all that is not Euclidean, and that the finite dimensions are just illusory stations in active zones of transition.”

Lars Spuybroek, *The Atter of Ornament* (Spuybroek, 2012).

Post-modernist pointillism I am often confronted with the same questions as the architect and designer Michael Hansmeyer whose layered paper columns get complex very quickly (Hansmeyer, 2010). Machines fabricating his pieces have a level of precision that can look like non-compressible visual random granular synthesis. Entropy seems at its maximum.

“The interplay of these processes over several generations can be manipulated to create ornamental form that exhibits an astounding degree of complexity. Unlike ornament generated through typical additive processes, these forms are not explicable through reductionism.”

Michael Hansmeyer, *From Mesh to Ornament* (Hansmeyer, 2010).

As we have seen before, the quantitative question of clarity is part of my interest in minimalism (1.3.3). I nevertheless think of my pieces as post-modernist.³⁸ The use of scale offers the possibility to create simplicity at a macro-scale from complexity at a micro-scale: a pointillist minimalism. I require the audience to have enough emptiness for interpretation.

I have not yet employed concatenative musaicing. But I am still interested in traditional collage, dada, techniques utilized by People Like Us, Matthew Herbert, Soft Pink Truth.³⁹ Now I have control of the structure, rhythm and form, I will do it in the near future.

³⁸There was a period I was much more obviously linked with post-modernism and worked alongside John Oswald with Plunderphonics or Otto von Schirach.

³⁹Coldcut, Satanicpornocultshop, ScrambledHacks, there are many virtuoso for collage sampling.

Limits of complexity

Perception has limitations, which allows for an integration of the information (The eye making a color from discrete RGB pixels). These limitations also have limits when attempting to understand a piece at a larger scale.



fig. 1.59 - Another snapshot from *Les Quatre Temps Cardinaux*. A narrow particle system is used as a grid for interference and perspective effects. This specific moment of the video is played together with singers soloists giving it a sense of wonder; as if it was a sunrise.

Continuity as a subjective characteristic Jean Claude Risset's paper *Pitch and Rhythm Paradoxes* outlines how he explored the possibilities of computer music at Bell Labs, and how these explorations developed into questions of perception (Risset, 1986). See his harmonic cascades or rhythm paradox for instance:

"In 1974, Kenneth Knowlton generated an ever-accelerating beat, which is the rhythmic analog of Roger Shepard's ever-ascending chromatic scale. We generalized this paradox and coupled it to pitch paradoxes. Thus we had produced a sound heard to go down the pitch scale, yet ending much higher in pitch than where it started. We imposed on it a rhythmical beat that seemed to slow down, yet ended much faster than where it began."

Jean Claude Risset, *Pitch and Rhythm Paradoxes* (Risset, 1986).

Time's linearity, for a more or less brief instant, varies subjectively. For example, an unexpected event causes us to skate over a portion of time. Elements perceived afterwards belong to a moment of readjustment (Grisey, 1987). This moment is necessary for the equilibrium, the focus. Here again, the observations of Cecil Balmond and Toyo Ito describing how a Noh actor moves from

one instability to another, become relevant (1.3.3). Temporal and consequently emotional values are moved by this disturbance inside memory: time has contracted. On the other hand, precise predictable repetitions give a more ample notion of time.

The longer we hold the impression of time passing, the closer to detail, to microscopic scale we concentrate. This elasticity does not only apply to physical time, but also to composition parameters. The exhibition at the MoMa, NY, called *Elastic Mind* included good examples of this concept. The neo-futurist architect Zaha Hadid's work demonstrates this analytic aspect of form. Irving Massey offered, in *The Neural Imagination: Aesthetic and Neuroscientific*, a question of energy transfer and satisfaction (1.2.2). One repercussion is the need to increase the sound level of music when being played with visuals.

This is a consequence of our limitation to perceive and apprehend, the outside world as an entirety.⁴⁰ This limitation could maybe a distant link to the uncertainty principle or possibly Erwin Schrödinger's cat thought experiment.

In any case, this limitation is definitely needed for the integration, the compression of a piece. This is why visitors see merged dots as lines, merged lines as grey level. This is why auditors hear pitches from the periodic repetition of discrete elements (1.2.3). I often refer to this as integration. I however know it is not mathematically integral. But I still see it as an area of calculation and as an averaging of continuous functions in computation and imagination. Information needs to be understood in order to be integrated.

Predictability and pseudo-periodicity Predictability and pseudo-periodic repetitions, loops and feedback, provide composition a physical degree of determinism, predictability, or a degree of determinism, predictability, or a degree of "pre-audibility" if time is involved (1.2.3). Time is perceptible, in opposition to being conceptually chronometric.⁴¹ I associate this degree of change (Veränderungsgrad) with musical anticipation bailed out by perceived pseudo-periodicity (1.3.2). The described periodicity has an isotropic character; it is horizontal, vertical, transversal: it has a perspective (fig. 1.60). For instance, Morton Feldman's *Patterns in a chromatic field* is like a Persian rug. It is both chronometric and "chromometric".⁴² I get the same impression with Merzbow or Zbigniew Karkowski's musics.

⁴⁰For more, see Immanuel Kant's transcendence or the *Simulation Hypothesis* concepts in Douglas R Hofstadter's *Gödel, Escher, Bach* or more recently Nick Bostrom's work (Hofstadter, 1979).

⁴¹Karlheinz Stockhausen understood the importance of this in *Carré* in 1971.

⁴²"Chromometric" is just an invention from me in order to add a timbral idea to time.

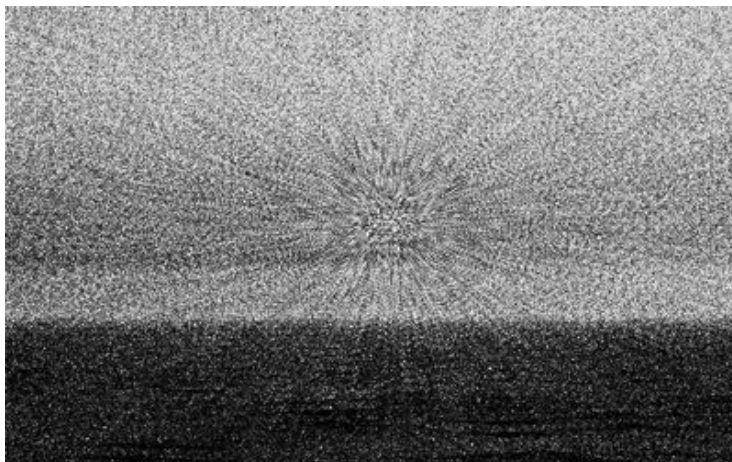


fig. 1.60 - *Les Quatre Temps Cardinaux* snapshot. A very specific photographic grain noise is added to slow-motion interpolated horizontal landscapes. I slightly delay and rotate noises and get interesting patterns.

Controlled structure of vagueness I am often confronted with finding the right group of settings for a specific result. Non-linearity avoids having one simple and direct result. My composition systems do not use computational optimisation, but my personal process has strong similarities to the optimisation process. Too many non-linear parameters are available, which force me into using intuitive experimental methods: I sometimes try experimenting in an intuitive way and see the result from this complex formalized system. My piece *β Pictoris f* is a typical example of this process.

If the composer applies the method inside the music itself, he will get a piece with patterns emerging out of masses (1.4.3). This is the case for Agostino Di Scipio or Curtis Roads's music (Solomos, 2005). The clearest examples do not have masses of sounds, but is rather a superposition of patterns converging or disappearing towards a simple and single pattern. György Ligeti's 1968 sound piece *Continuum* or Casey Reas' 2014 visual piece *pfft* both move in this direction.

"A composer who knows exactly what he wants, wants only what he knows-and that is one way or another too little."

Helmut Lachenmann, *Composer in Interview: Helmut Lachenmann*,
(Lachenmann and Ryan, 1999).

The post-modernist composer Kyoka is a good example of Helmut Lachenmann's aphorism: her music has a form, even though she does not seem to control anything at anytime.



fig. 1.61 - *Alpha Centauri I* is a large hd print from 2016. I here use ray tracing over a generated waved landscape. Beyond its pure abstract interest, there is a strange similitude with the Occator crater on Ceres. This may be a dedication for the 1989 Iannis Xenakis's *Voyage Absolu des Unari vers Andomede*. One can see a taste of moiré and poly-rhythms here too.



fig. 1.62 - Zoom of the rendered *Alpha Centauri I*. I virtually use a special material made of glass with strong diffuse reflections and non-homogeneous colors. Beautiful saturation is visible in the bright parts; the material is here too reflexive for the amount of light.

Lars Spuybroek talks about a *structure of vagueness*. He tells how Frei Otto used analogue computers to find forms by computation rather than defining them from formulas because formally finding the right form would require more precision in the description of the model (fig. 1.24) (Spuybroek, 2005).⁴³ This is another way of composing, not by adding or subtracting elements, but rather by finding the best fit for a target:

“Continuity, or vagueness, understands things in the opposite way to what we know as elementary, not as prior to relations but as a posterior result of relationality. It is a universe where relationality is a given, and things – objects, beings, events – emerge from it. It accepts dimensions as much as Euclid’s elements; it just doesn’t accept them as discontinuous, only as generational, as sprouting from one another.”

Lars Spuybroek, *The Structure of Vagueness* (Spuybroek, 2005).

Form finding involves constraints from outside the object itself. There is no need to fully understand the system: feedback and feed-forward processes optimised by computation eventually and “naturally” find solutions. Another example in music, orchestration has many constraints. This is the reason why generative orchestration uses genetic algorithms to propose well fitted timbres (1.2.1). For example, the *Orchids* software is one good tool for generative orchestration (Hackbarth et al., 2013). Such computational methods let emergence propose several solutions arising from a noisy and complex environment.

Computational experimental method The experimental method described in the previous paragraph seems rather peculiar for composition (1.4.2). Formalizing a problem then solving could potentially be difficult and not useful for the arts. But using computation does not prove or generalize anything either. It is still interesting to correlate my workflow with a computational experimental method.

Iterating attempts while correcting them, with a subjective fitness, does not generalize anything. But it can just fit the needs, or provide a desired outcome without reasoning. Computation becomes the outcome of a “novel” experimentation paradigm. Achim Menges talks about this type of computational material synthesis. He describes the idea Stephen Wolfram intensively explored in *A New Kind of Science* (Abdalwahid, 2013). I personally feel that simulation, optimisation and computational form-finding are possible with iterative machines such as computers, printers, scanners and all other computational machines. For in-

⁴³Frei Otto was after minimal surfaces (1.3.2). Tensile and membrane structures were found using a mechanical technique; I am certain for the 1972 Olympiastadion in Munich.

stance, Achim Menges pavilions are all fabricated with computational design using iterative processes; not only with 3d printers but a large variety of machinery and concepts:

“A modern engineer would have started with a set of formulas establishing causal relationships between loads, forms and stresses in the structure. Typically used to calculate the resistance of a structure after it has been designed, these formulas can also drive and inspire our first, intuitive design of it. This is because causal laws make sense, somehow.” (...) “That does not apply to our current way of designing by form-finding, or - as I would say to better demarcate the computational nature of today’s process of optimisation from its physical precursor - form-searching. The power of big data applied to information retrieval and simulation makes the formulaic data compression at the core of modern structural engineering as obsolete as the Yellow Pages.”

Achim Menges, *AD - Material Synthesis - A New Science of Form-Searching* (Menges, 2015).

Deconstructivist stratification Deconstructivists like Rem Koolhaas or Frank Gehry know well the question of complex forms built from the superposition of many simple materials. They have no choice but to use elements simpler than they prefer if they want “non-standard” architecture to become real (Oosterhuis, 2009).⁴⁴ The architect Kas Oosterhuis tells about the importance of stratification both for conceptualizing and fabrication. He refers to separated skins that are also making one single element with communication. Because he is an architect, he transposes this idea up to functional categories, and probable social consequences:

“Division of components into functional categories (like steel structure and facade structure) and executed by different parties, which is the basis of traditional process of tendering and contracting, and on the principles of mass-production, is counterproductive to the principles of nonstandard architecture, which is based on the principles of (mass) customization. From now on we need to think in inclusive Design & Build contracts, where all parties involved including the fabricators, are collaborating in the design, engineering and execution phases on an equal bases respecting each others expertises, to find the adequate built solution both esthetically, technically and financially, which will not be a compromise but in essence an innovation.”

Kas Oosterhuis, *What exactly is Nonstandard Architecture?* (Oosterhuis, 2009).

⁴⁴ *Architectures Non-standard* at the Centre Pompidou and *Elastic Mind* at MoMa were very important exhibitions for me (1.2.2).

It is not easy to get something other than textures from several layers of granular synthesis (1.4.1).⁴⁵ This is the same difficulty deconstructivists encounter. Wavelet analysis-synthesis is a good example for concatenation and layering. It consists of a dictionary of superposed short grains that reconstruct a target sound. This type of transformation and assemblage also matters for the layering of neural networks' map (1.3.2). This will definitely be a direction of research I will go into.

Such collage concatenation methods can be done not only in time, but also in any other compositional dimensions. For instance, Ben Hackbarth builds the excellent *AudioGuide* for also concatenating vertically. I regularly use his synthesis because of its efficiency in use and musical sense of time.

Such aggregations and their resulting stratified constructions lead to post-modern dada pieces. Gábor Lázár's music in the 2010's, for example, is based on rhythmic and pure harmonic additive synthesis. It is again a very simple but efficient "Persian rug" where the notion of form is at its most basic. Marcus Schmickler's electronic pieces are more focused on a vertical dimension while also remaining simple. These two composers are much more elementary than Ivo Malec or Toshiro Mayuzumi who compose additive synthesis like a classical instrument with separate perceived elements (1.4.1).



fig. 1.63 - Extract of the generated score for the intermission of the theater piece *Songes et Métamorphoses*. The poly-rhythmic notation is obviously not convenient for playing. But changes of metric for each voice are here useful for reading each voice independently while seeing the overall synchronicity. Horizontal spacing can be read as the time-line of tracks. The process consists of the shrinking and extending of loops. Duration of all bars are independent from what they contain thanks to a tree representation using Jtol in real-time (1.4.2). The outcome is a multi-scale poly-rhythm where each layer is here independent. Complexity can quickly appear but a sense of relative acceleration can sometimes emerge.

The choice for additive synthesis in my pieces goes beyond the idea of transformations described earlier; it is truly a question of aesthetic choice with stratification (1.4.2).⁴⁶ The increase in computational power and the development of

⁴⁵See the interesting piece *Suite N* from 1982 where Jean Schwarz uses additive synthesis in acousmatic music.

⁴⁶I can use Miller Puckette's 3F synthesis, harmonic opcodes from CSound such as buzz, oscbank~ in Max or sinusoids~ from the CNMAT. But I often add sympathetic resonance.

new techniques, such as the phase vocoding, have large been advancements for additive synthesis which has seen its amount of possible oscillators and consequent richness of sounds drastically increase. But remains my taste for coldness and the purity fixed additive synthesis can give. I nevertheless voluntary articulate each “partial” with a sweeping attack, giving the signature of an acid FM or subtractive synthesis with the index or center frequency changing over time. The result from one single element sounds very much like the sounds from 1980’s computer music.

Russell Haswell or Rashad Becker deals with complex textures in their work. Russell Haswell acquired a unique dexterity using a single chaotic oscillator allowing him to improvise with non-linearity. In a sense, he is tickling the dragon’s tail with one single oscillator.⁴⁷ In another field and another period, the architect Antoni Gaudí also had a control on simple unique morphogenetic forms thus enriching his pieces.

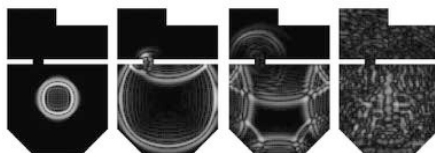


fig. 1.64 - Waves propagation in a room have a tendency to be fractal with a strong sense of symmetry (1.4.1). The developed patterns are ripples marks, made of rugosity.

Symmetry and rugosity Rugosity is usually a measure of small scale height variations on a surface. I use this tangible feature, for the ear and the eye, in order to characterize tiny structural variations. I previously explained I was tickling the dragon’s tail with parameters (1.4.2). These tiny deviations have no influence on a macroscopic scale. It is rather more a texture at the scale of timbre and variations make this texture palpable. This is the case with a fast beating effect between two signals. It deals with the material property of the skeleton of a piece, its structure.

Structural regularity has often been a feature of minimal music. Minimalist work is based on repetition and, here again, questions about reproducibility and industrialization arise. I explained earlier my interest in series, consistency and radicalism (1.2.3). Fundamental frequency, periodicity, into music is a primary aspect with horizontal and vertical rhythmic symmetries as a central game (1.4.2). Because of the relative simplicity of these initial rhythmic patterns, they eventually are involved with anticipation and predictability (1.4.2). The exac-

⁴⁷“Tickling the dragon’s tail” was an expression from the physicist at Los Alamos when dealing with critical mass for the atomic bomb.

titude of looping mechanisms played by machines enhances a monotony which allows other levels of subtlety. It is interesting to see how Mark Fell’s processes are closely related to Philip Glass’s (fig. 1.67) (Gann, 2013). Philip Glass’s master piece *Einstein on the Beach* uses variable sized loops and rhythms. The insisting sensation of repetition provides a continuity, setting the listener into a state of trance. It is not a drone, but ends up as a similitude: without surprise the music stops being sonic and then enters into a more transcendental state (1.2.1).⁴⁸

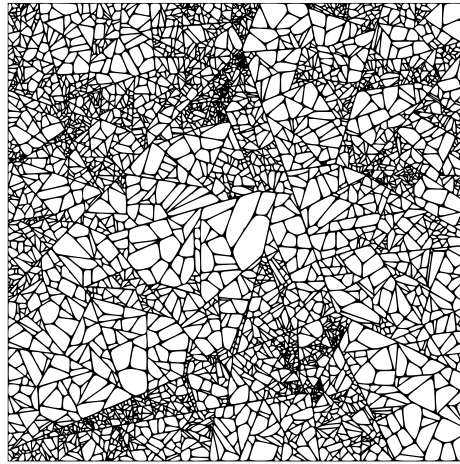


fig. 1.65 - Simple 2d Voronoi diagram made with Rhinoceros 3d ^{48b}. It decomposes the plane according to a set of points (seeds). A line is drawn for each equidistant point; this is a Voronoi diagram. Resulting regions are called cells and are useful for data visualization. It is interesting to see how the mind clusters points easier using proportional surfaces (1.3.2). Also, the relative positions between points is shown by the pattern of cells and group of patterns. Symmetries are easily detected or build this way (McLean et al., 2007). This is only useful with more than one dimension because it is again a question of mapping, correlation and auto-correlation between parameters (1.3.2).

In my work, I sometimes consider reverberation as a finite computational ornamentation (fig. 1.64).⁴⁹ Its fractal aspect comes from the form of the hall. Its almost repetitive, pseudo-periodic property, comes from early reflexions against the same walls. This creates pseudo-symmetry patterns and thus interesting moiré patterns.

Similarly in computer graphics, objects are built from nested primitives which are initially symmetrical in order to fit together into a closed (complete)

⁴⁸Music based on step sequencers are very good at that and it is the easy reason they are so popular in dance music. Active listening then becomes different with added tangible factors.

^{48b} The picture is actually a little more straightforward than a real Voronoi diagram. I made here a substrate algorithm inspired by Jared Tarbell to provide a sense of nested hierarchy to the diagram.

⁴⁹The impulse response of a room can be represented by a multi-fractal (Pavlović and Ristić, 2011). I experimented using a “brute force” ray tracing rather finite element (Schietecatte et al., 2012).

tiling. These multi-dimension rhythms are thus intrinsically symmetrical at one scale or another, or a moment or another. Symmetry has a close link with periodicity. The fundamental frequency of a piece, then reveals detected patterns which makes the piece understood for the ear or eye: symmetry lies in the middle of the compass of beauty (fig. 1.65) (Whorley et al., 2013).

β *Pictoris c* and *The Nothing, Seeking Answers: Indivisible Streams* use a series of nested modulo and trigonometric functions. The manipulation of their phases achieves a strong sense of periodicity (1.4.2). Predefined parametric limits, such as the denominator of a modulo operator, create rotations, folding, origami, so an apparent periodicity out of initially randomness. A reorganization of the composition space reorders information within it. Iannis Xenakis used modulo in a deeper way (Xenakis, 1992). His timbral stochastic synthesis together with modulo in his Gendy engine generates a wide and controlled variety of sounds out of (Serra, 1993). I personally prefer simplicity which allows me to adapt parameters in multiple dimensions.

The Nothing, Seeking Answers: Indivisible Streams is a piece that applies a specific periodic formula which can be seen in the figures fig. 1.48 and fig. 1.53. This function, in 1.66, uses 300 micro-tonal voices which are in relation with several layers of nested periodic functions. Time is quantized to a specific quantum duration.

$$y = \cos(\sin(\tan(\sin(\sin(\tan(x \times \pi))) \times \pi))) \times \exp(\sin(\tan(x \times \pi)) \times 0.015)$$

fig. 1.66 - Trigonometric function used for *The Nothing, Seeking Answers: Indivisible Streams*. The function is used for all 300 frequencies of the spectrum. The x variable can be time and y frequencies. x is also the frequency, and y the dynamic. This orthogonal shift of dimension creates a piece which is symmetric in its several characteristics. It is not directly understood by the listener but it provides a sense of coherent construction.

An initial phrase, initial state, gets shrunk before growing again. It uses Jtol (1.4.2) so this can either be done with entire or rational duration. The tree structure allows a-synchronous elements within a larger one which is synchronous in order to control a complexity. These are the layers described earlier; I use this loop and phase technique in order to get moiré effects (fig. 1.67).

The formula varies for *Master Rock* but the ideas of periodicity and phasing remain. I use rational variable durations instead of using fixed loop initial elements (2.2.1). The difficulty consists of avoiding having too many shifted voices that would make periodicity long and too diffused: the outcome can rapidly become a texture.

Quantization is one solution for controlling the sensation of symmetry. The

fact I use tree representations with Jtol helps (1.4.2). Using branches, I force any duration division to remain constant within branches. Each entire duration of branch is independent from what it contains (1.4.2). I therefore get a constant pulsation with many complex and random rhythms inside. With several voices, this technique allows me to control phases. Tree representation allows me to apply this technique at several depths and also to apply random swing to different levels of the tree structure without getting into a mess. This randomness added to the periodicity creates the *rugosity* of my rhythms.

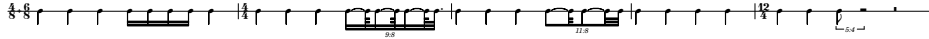


fig. 1.67 - A simple layer example of a rhythmic phrase for *Master Rock* (2.2.1). The phrase gets shorter and shorter before it grows again. Made with Jtol, this system allows the shrinking of phrases from both sides (1.4.2). This can either be done with entire or rational duration. The tree structure allow a-synchronous elements within a larger one which is synchronous. Complexity can therefore also be controlled with this. This looped and phase based technique is very useful in order to play with moiré. Here is what happens with a tree representation:

$$\begin{pmatrix} 1 & 1 & 1 & 1 & (& 1 & 1 & 1 & 1 &) & 1 &) \\ (& 1 & 1 & 1 & 1 & (& 1 & 1 & 1 & 3/5 &) &) \\ (& 1 & 1 & 1 & 1 & (& 1 & 1 & 1/5 &) &) \\ (& 1 & 1 & 1 & 1 & (& 4/5 &) &) \\ (& 1 & 1 & 2/5 &) \end{pmatrix}$$

Playing with entropy: the edge of chaos Earlier I explained some methods for experimenting with feedback in *Joyeux Animaux de la Misère*. More generally, this feedback is for me seen as an iterative computation; as much as ray tracing is for reverberation.

I find recursive processes difficult to control, whether they are timed or not. For timed processes, it is indeed difficult to guess the future; dosing a transformation with the proper amount of delay, feedback and feed-forward is a delicate procedure (1.3.2). The parametric space used for *Master Rock* exemplified this concern because it is made of many short gains.⁵⁰

So I constantly tickle the dragon's tail (1.4.2). I can lose control of feedback loops which results in oscillation. This oscillation is actually chaotic from the point of view of the user, the system itself and the interrelation between user and system. At the edge of oscillation is the edge of chaos.

Eraldo Bernocchi and Thomas Fehlmann who collaborated together, in 2009, on the album *Manual*, are virtuosi at walking on this edge; they make clever dub music.⁵¹ Richard Devine and Syndrone sometimes use analogue synthesizers to

⁵⁰Multi-agent systems are supposed to use relatively simple rules and their complexity spreads from the iteration of their process.

⁵¹It would be interesting to see dub using a feed forward control.

effectively compose using feedback rhythms.⁵²

At this edge of chaos lies a boundary between subjective randomness and understanding (1.3.3). “Computation at the edge of chaos” is generally used in complex systems and artificial life . I believe the most interesting part of creation lies is where both understandable and subjective randomness interact with one another; the chaotic part of the equation.

“Simplicity is complexity resolved”.

Constantin Brâncuși.

Constantin Brâncuși was not thinking about chaos when he wrote this. But his definition of conceptual and physical minimalism emphasizes the chaotic boundary. As a sculptor, he was building forms by ordering in a subtractive way; he would sometimes start from a random stone.

I have a deep admiration for artists who have understood how to balance on the chaotic boundary. For instance, Ryuichi Sakamoto’s wide stylistic range of music has always been simple to me. His simplicity is the result of decisions from his senses and maturity. This is, for me, the lifetime research I pursue and described earlier (1.2.3). Sakamoto knows how to follow the drive of people on the line of coherence.⁵³

The architect Tadao Ando creates a haiku effect with his work. He emphasizes nothingness and empty space to represent his ideal of simplicity. Haiku is the art of cutting or punctuating. Everything relies on how rhythms are set in terms of harmony (proportions): when to start and stop according to contexts created by the entire piece; at all scales. François Morellet’s work does not involve haiku, but it poses questions of quantities as qualities; thereupon minimalism (Pacquement, 2011). Kazuyo Sejima and Ryue Nishizawa from Sanna go in a smoother way. Their ratios are more continuous and apply smooth parametric curves to their creations. This is how I see the work of neo-futurist architects like and Santiago Calatrava.⁵⁴

1.4.3 Emergence

From pattern to form. Patterns built at the infinitesimal scale spread over time and space; they are the initiators for the emergence of larger scales and eventually form: gestalt.

⁵²See the work of Asmus Tietc.hens and Arcane Device both virtuosos of their feedback machine to both generate timbre and rhythm. They worked together.

⁵³See also Roberto Crippa or Robert Lippok. Their dark and heavy music seems noisy but amounts are just right and make them light enough to get an impression of greatness.

⁵⁴See how Buckminster Fuller materially conceives the world.

Morphogenetic emergence and negentropy

In the previous sections, I describe a specific composition system as a poetic view of an artificial nature, which can be explored with active reading or listening (Codognet, 1998) (1.2.2). I described it in a static way: my processes lack the autonomy that enables the listener, or reader, to have a full sense of aliveness. Further displacements, from a higher level, are needed for the process to exist (1.3.3). A needed evolution has to emerge from the complexity of my composition systems as if it was autonomously appear. I see two related views for emergence to come out.

It first can be left free: letting it go with the expectation that randomness will eventually emerge. Entropy intervenes and its direction, more precisely its sign, leads to a kind of voluntary disorder and degradation (1.2.3) (Krause et al., 2001). The latter are initially defined by the composer who created some natural order of evolution within a system.

This is the case for early artificial life artists such as Karl Sims or Laurent Mignonneau and Christa Sommerer create computational evolutionary systems that eventually converge to a specific artistic goal. Their evolutionary algorithm is a genetic algorithm inspired by the process of natural selection. This together gives interesting results and a rich source of inspiration from Nature.

This is also the case for formal grammar based systems such as cellular automata, L-systems and other discrete computational models (1.3.4).⁵⁵ For instance, the media artist Peter Beyls is one interesting pioneer in this field (Beyls, 2010). He uses usual 2d cellular automata processes as a piece. The specificity of the piece being what he composes with such generative tool.

This is also the case for artists preferring the use of iterative processes like chaos, fractals or various number theories. One can think of Michael Gogins and his electro-acoustic pieces emerging from one single fractal formula.

But instead, a subjective direction of entropy can be controlled using supervision.⁵⁶ If there is a control, then there needs to be at least two entities; one controlling and one being controlled. Such guidance should then be outside of an inner controlled process. Iannis Xenakis beautifully describes them in *Formalized Music* (Xenakis, 1992). Also, bayesian approaches use the probability of occurrence of ordered states to within a sequence. The order of occurrence being important. The third law of thermodynamics within an inner process is resisted (Hiller, 1982).

We are here talking about negentropy which is the negation of entropy. As Erwin Schrödinger describes it for biology, the factor of organization is here

⁵⁵George Stiny and James Gips were pioneers for shape grammar (Stiny and Gips, 1969).

⁵⁶This is the same supervision used for some neural networks starting their learning process from random weights.

opposed from the laws of physics to keep structure and form ordered as wanted. The latter are being maintained *alive* by external factors such as food in the case of biologic cells, or information for agents.

“(...)a living organism continually increases its entropy -or, as you may say, produces positive entropy -and thus tends to approach the dangerous state of maximum entropy, which is of death. It can only keep aloof from it, i.e. alive, by continually drawing from its environment negative entropy -which is something very positive as we shall immediately see. What an organism feeds upon is negative entropy. Or, to put it less paradoxically, the essential thing in metabolism is that the organism succeeds in freeing itself from all the entropy it cannot help producing while alive.”

Erwin Schrödinger, *What Is Life? The Physical Aspect of the Living Cell* (Schrödinger, 1944).

Emergence from a bottom scale

I agree with Bernard Stiegler claiming that nanomutations are the convergence of technologies of matter, information and living entities (Stiegler, 2006) (1.3.2).⁵⁷ This reaches, in a more limited field, my thoughts about fabrication and materialization of music emerging from infinitesimal scales (1.4.2).

D’Arcy Wentworth Thompson wrote *On Growth and Form* in 1917. He describes the notion of emergence originating from microscopic computation (Thompson, 1942). For him, emergence always comes with growth and then appears from a smaller scale. The idea is a consequence of Art Nouveau, the revolution of microscopes, and the rise of quantum theories in the early 20th century (1.3.2). Things did not really change nowadays for that concern: experiments at the Large Hadron Collider and Fermilab are nothing but large spatial and timed microscopes and a strong source of inspiration for the arts.⁵⁸

In a 1968 interview John Cage and Lejaren Hiller together openly talk about *indeterminacy* using machines (Austin et al., 1992). John Cage sees emergence also from the interpretative point of view rather than from the mechanical system alone:

“Another will be the Dice Game that has been attributed to Mozart, of which 20 passes of 64 measures each have been programmed by the computer (...) All of that material can be superimposed in any way. So it could produce a variety

⁵⁷Bernard Stiegler is more interested in the social consequences of those nanomutations.

⁵⁸This is the same with telescopes and space probes.

of performances. Parts can be omitted. The performance can consist of, say, a dozen people with a battery of tapes, shifting the tapes from machine to machine, and so on."

John Cage, *An Interview with John Cage and Lejaren Hiller*,
(Austin et al., 1992).

This lack of expectation from the human side feeds a sense of narration (1.2.2). In this case, the emergence of a piece does not come from growth, but rather from the interaction between discrete elements: the system, its interpretation and the audience. But these elements can be thought as one whole system if the audience is considered as being part of the piece. And one can think about a growth emerging from the interaction between smaller elements.

I personally did some early experiments with Philippe Codognet at the University of Tokyo using multi-agent systems with constraints on ants and their pheromone (Pasquet and Codognet, 2009). I also worked using a more constrained Markovian approach at Sony CSL with François Pachet (Pachet et al., 2011). These two early experiences were both a starting point for this consequent inspirational and aesthetic direction. They showed me that form generation was coming from scales. I understood that scaling was primary because it is the actual spatial matrix from which generation can occur. Without scale, there is no possible change; there needs to be a gradient; at all dimensions.

Emergence from neural networks

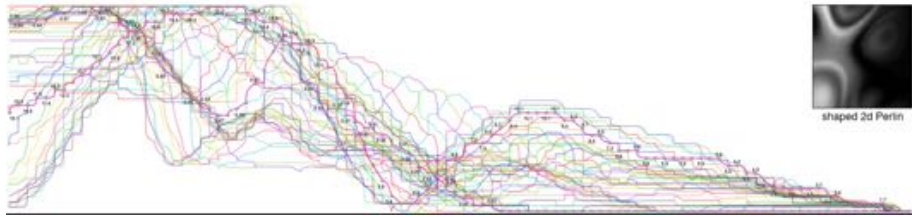


fig. 1.68 - In β *Pictoris f*, the evolution of parameters is defined by a 2d Perlin noise (upper right). Interpolated and quantized break-point functions are here superposed to see the relation between parameters. I use two dimensions for convenience.

Emergence is for me a central key in the way I use neural networks. A simple perceptron starts from random weights until a pattern emerges after iterations during the learning process. Such a system is used for classification of pre-existing patterns. But it can also be used for creating forms apparently out of complete randomness.

Some artists like Frédéric Voisin have used recurrent neural network for decades because they are useful for iteration based processes (Dubnov et al., 2003). Many composers in the 2010s now use Gruv, WaveNet or Magenta.⁵⁹ I hear more and more concatenative tests or pieces on Soundcloud that are a collage like microscopic dadaist or breakcore pieces. The composer Evgeniy Vaschenko is one of the many interesting user of such system. He uses smaller and smaller scales for concatenation and now moves from a musical sample size to the one of audio sample.⁶⁰

I also previously used such approaches when I was more maximalist than I am now. I indeed used to classify samples from their MFCCs and later concatenate them using the Lempel–Ziv–Welch sequence method similar from the zip data compression algorithm. I was doing clustering, classification, and could have used neural networks for that. I will undoubtedly eventually come back in this direction of research.

Artificial creativity using unsupervised form generation

Connectionist systems are mainly used as recognition, optimisation and classification tools.⁶¹ This is the reason why people mostly use them for concatenative synthesis and not for generating patterns from scratch.

I earlier intentionally amalgamated the notion of emergence with autonomy. Most of the examples make use of a previously learned database (1.4.3). The fact they did use an already existing knowledge does not make them totally autonomous from the very beginning of the creative process. Neural networks, as a finite computational system, perfectly fit with my previous work with parametric and computational composition. So I personally tried to use them differently and avoid any supervision.

The knowledge of my neural networks is located inside layers of 2d matrices, including hidden layers. The initial state of each matrix is inside noise. I then use the network like a usual optimisation tool by generating several generations of matrices until it reaches an intended coherent pattern. That consistency goes in all directions and also all layers of matrices. These layers are the deconstructivist stratification described earlier. The final pattern emerges from form fitting (1.3.2). But the interesting part of the process happens between the initial and the final state; when over-learning has not been reached yet.

The way this series of matrices are generated and eventually reach the final state is important. I use the generative methods described earlier because

⁵⁹Magenta is part of Tensorflow from Google but for musical purposes.

⁶⁰There is a large variety of concatenative synthesis. But they are more timbral and a quite few take time into account. See the work of Diemo Schwarz and Ben Hackbarth (Schwarz, 2013; Hackbarth et al., 2013).

⁶¹This is mostly the case for multi-layer perceptrons or self-organizing maps.

they are good for building sequences and versions of sequences (1.4.3). For my artwork, I saw no difference between genetic algorithms and cellular automata rules for generating these weights.⁶² The final coherent pattern is nothing more than Brownian noise. The main reason is that genetic algorithms are mostly used for optimisation so they need to have a defined plot for evolution. In my special case, I do not care about the plot and I am rather more focused by the evolution itself; without any problem to solve.

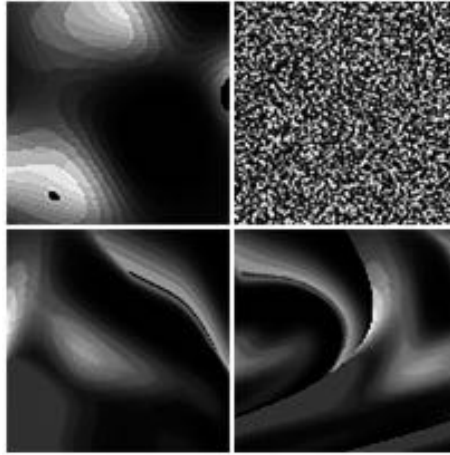


fig. 1.69 - In β *Pictoris f*, the evolution of parameters is defined by a 2d Perlin patterns modulated by other various quantized textures (upper left picture). This pattern is then analysed by a *recurrent neural network* which generates a grammar usable as a 2d cellular automata system. In this example, each 12 neighbor pixels define a center pixel value. The upper right picture is the initial white noise pattern. After iterations, it eventually give an versioned interpretation such as both pictures at the bottom.

But I could also have used Tensorflow for instance. This powerful library consists of representing time by shifting input vectors and advance sample by sample.⁶³ But my “black box” creates at least multi-dimension results rather one time-line (fig. 1.69) (Tremblay and McLaughlin, 2009). These multiple dimensions are in relation and can be used for mapping parameters. I decided to build the system myself in accordance with Jtol and the bach library (1.4.2).

Perlin noise patterns as initial spark

As with *The Nothing, Seeking Answers: Indivisible Streams*, my piece β *Pictoris f* uses a parametric approach using multi-dimensional Perlin noise (1.4.1). Perlin matrices conducting trajectories that are mapped to synthesis parameters, as explained here: 1.3.2.

⁶²I used the Galapagos library in Rhinoceros 3d.

⁶³See the excellent article about NSynth (Engel et al., 2017).

I use multi-dimensional Perlin noise because its fractal characteristic provides a cohesion at all scales and all dimensions: one parameter is in direct relation with its neighbors. One moment, or position, is in coherence with the previous and the next one. Neighborhood also fits with the use of cellular automata used for the making of neural network weights.

We here only care on a coherence between states and not so much on specific patterns. So brown noise is therefore useful also because of its recursive characteristic. I actually use a lot simplex noise is another noise very close to Perlin noise. Its algorithm allows a control of its harmonics, so a control of recursive layers. With this kind of noises, parameters are in direct relation with one-another: when one goes up, another one goes down, or up, etc. Only the second derivative, acceleration, inflexion points, remain unchanged between parameters. Also each dimension of this multi-dimensional Perlin noise sets the relation between sets of parameters; one coordinate of the space is simply used for one parameter. It is rather interesting to scramble coordinates between parameters and still get a coherent but different form.

Auto-organization building a synthetic structure

The sources of inspiration described earlier have the apparent tendency to be a generalization of a theory. The fact I still consider my pieces as unique makes these ideas not truly generalized. The only need for them to be generalized is the ability to be reproducible. The reproducibility I am after can eventually lead to a style; some kind of autonomous universe.

In *Harmonices Mundi*, Johannes Kepler generalizes a universe that is not exact (Kepler, 1619). The fact he is correct with Nature does not matter to me. The importance for me lies in the fact he builds a world that can live by itself (fig. 1.70). There is no need of proof and the beauty of reasoning matters. There is no need to turn data into evidence; unlike Isaac Newton's who was a pioneer about this.

More recently, Dennis Gabor's infinitesimal quanta proposed agglomerate assembly particle systems as pure information. As I am interested in quanta, I see his researches as a kind of *artistic information theory*. The reproduction mechanisms I am using are just waiting to one day totally become totally autonomous from the beginning. I am willing to generate an infinite series of unique pieces that are nevertheless not generalized (1.2.3).

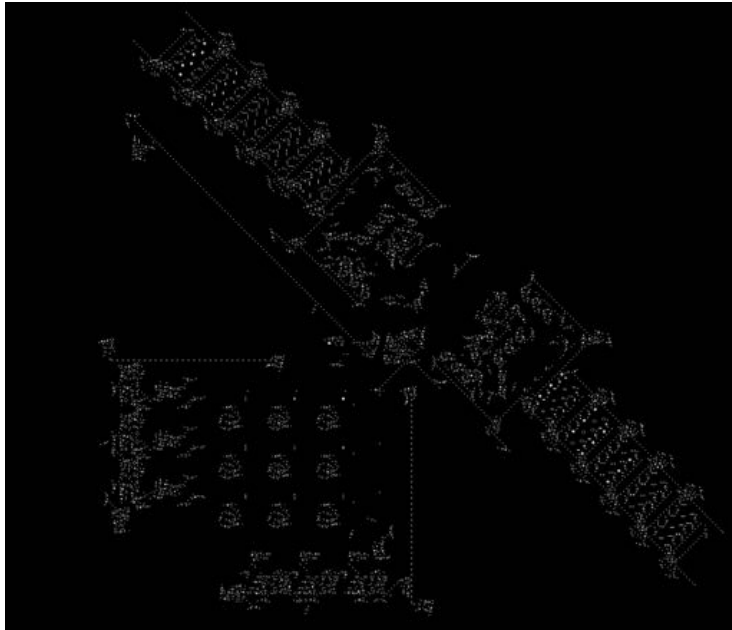


fig. 1.70 - Snapshot of a large Conway's game of life of a scale 3-symbol Turing machine. I re-arranged it myself for a future piece. This game of life is reproducing , or reorganizing itself only from internal rules.

My current interest for deep learning and machine learning approaches come from the 1960s: strangely the same period of the aesthetics that interest me. Many of these tools are somehow biomimetic and romantic. I sometimes wonder if we are not currently living in both a modernist and romantic period where calculation overlays thoughts.⁶⁴ A period where we are all playing a game with a complex iterative simulation; the simulation hypothesis. The outcome of this simulation hypothesis is maybe a zeitgeist; like a formal style of the cultural moment.

“The SOM is able to learn to recognize different patterns in the input data and allocate them to appropriate “bins” (styles) in the output array, each bin representing a specific pattern. Therefore if we see the output as an array of “classification bins” (each representing a specific pattern in the input data) that are arranged in an ordered way such that near neighbors represent similar styles and distant neighbors represent different styles.”

Shlomo Dubnov, *The Structure of Style* (Argamon et al., 2010).

For instance, in his book *The Structure of Style*, Shlomo Dubnov describes how *self-organizing maps* (SOM) can be used for classification. The fact this

⁶⁴Connectionist techniques also use inference as seen in 1.4.3 (Hofstadter, 1979).

type of neural network has no supervision allows a categorization of style from a large amount of common pieces. Remains the question if the outcome is culturally relevant and is not only blindly computational (Argamon et al., 2010).

The post-romantic composer Gustav Holst treated the subject of an artificial universe with *The Planets* and many other pieces. It is still nowadays a question of the perfect synthetic structures; a control, understanding and transcendence of nature. One of the most interesting electronic composer who created his universe, in a literal sense, is Matsuo Ohno with his work for Osamu Tezuka's *Astro Boy* or *The War in Space*.⁶⁵

Again here, the ultimate work piece is not only demonstrating a generalization that only composes automatically. It is rather a question of reproducibility and industrialization of such processes.

Assumption of an autonomous and self-reproducible fiction

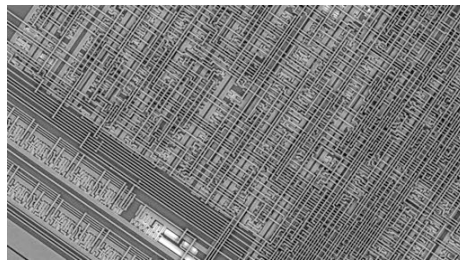


fig. 1.71 - A computer chip is a descendant of the universal Turing machine. Its design uses nested patterns and its construction is done at an atomic scale (1.4). It represents an enormous amount of man-hours that can only be designed by a machine. A machine designing and building a new machine for the same machine.

A multi-dimension Perlin noise matrix is the very start of the generation process. This *initial spark* apparently emerges from nowhere, although it is believed to be composed. The appearance of autonomy is purely subjective from the public (1.3.4). Turing test and schemes of anthropomorphism are important for my generative pieces to exist autonomously.

I am willing to go much further than just a pattern and form generation. I indeed have the fantasy of self-determined concept, independent and ubiquitous (Mock et al., 1983). It is the Heisenberg principle previously described (1.4.1): the assert there is a limit of precision in the position, and momentum, of a particle for instance. This means one does not know where a particle is; so there is an uncertainty of identity or several positions at the same time. The

⁶⁵What the electronic music studio of the NHK did between the 1960s and 1970s is very interesting.

fact my pieces are generative allows the making of an infinity parallel versions at any time.

I often tell about information reproduction; the reproduction of a generative piece. I still have to mention self-replication of pieces as John von Neumann and Alan Turing conceived it. Not only is information reproduced in their case, but also the mechanism that builds the actual information (fig. 1.71). The adaptive meta-system in β *Pictoris f* is going in this direction, but it is not enough for self-reproduction (1.4.3). But it would be worth going further with synthetic biology:

Anybody who looks at living organisms knows perfectly well that they can produce other organisms like themselves. This is their normal function, they wouldn't exist if they didn't do this, and it's plausible that this is the reason why they abound in the world. In other words, living organisms are very complicated aggregations of elementary parts, and by any reasonable theory of probability or thermodynamics highly improbable."

John von Neumann, *Theory of Self-Reproducing Automata*
(von Neumann, 1966).

Parallel instances of pieces should be compared one to another and evolve accordingly; a genetic algorithm or any evolutionary algorithm could be used. Reproduction would take care of previous versions as it does for autonomy. But it should also care about how the presentation, the performance, of previous versions was materialized within an un-controlled context; within a public, a concert hall etc.

Negentropy plays an important role here (2.2.1). When a piece is one entity made of concepts, those concepts can only reproduce themselves and evolve within an external medium. Any reproduction within the entity belongs to the entity: two instances must be able to be compared. External elements interfering with the conceptual entity can then only be un-controlled because they would otherwise simply be part of the concept (2.3). Entropy can indeed be thought as the direction of a displacement. If there is no inside and outside, there is displacement so there is no entropy, so no evolution.

A material piece often needs physical reproduction mechanisms to (re)produce itself in reality. But if displacements remain conceptual they can easily be integrated within another concept. So they only remain autonomous and not self-reproduced. There needs to be an external component, or a representation of the external component: a *fictive artificial nature*. And this is what we are going to see in the next part of this text.

1.4.4 Transition

I chose to organize information in a tree structure. This is a natural way of conceiving composition. It also easily allowed me to leave self-organization operating at various scales and proportions from the infinitesimal to the macroscopic scale. I built an entire library of tools focusing on rhythmic processes using randomness and possible emergence. Trying to compose a series with infinite variations lead me towards conceptual art. I therefore needed a meta-workflow that could construct self-similar sets from the complexity of the system. Experiments with genetic optimisation led me to a unique connectionist way to build multi-dimensional parametric bodies. I decided to use recurrent neural networks in which neural weights and positions are ruled like cellular automata. This particularity gave me a taste of autonomous self-reproduction. This conception invites the audience to surf along the edge of chaos with randomness and complexity. The interpretation of the latter raises questions of belief and interactions with the apparent real world.

1.5 Conclusion

The previous chapter describes my historical inspirations and how they eventually lead to a general but personal research field. An open definition of a score for electronic generative music brings me to a specific parametric mapping. Time is treated as any other parameter. Depending on how much the parameters are perceived as continuous, their evolution can be considered as waves or discrete particles. I decided to work with rhythmic tree representation processes at infinitesimal scales. They autonomously spread to larger scales. The piece then becomes reproductive at a large scale and can possibly create series if not consistency in the style. We have seen that, even for pure electronic music, interpretation from the audience is crucial. The exploration of limits between what can emerge, be perceived, and how it can later be characterized becomes part of the composition process. It is then probably a sort of media art where the final chosen medium ultimately changes the perceived piece. One recurrent difficulty in my work is the passing from the imaginary concept, its conception, to the actual materialization. It is not a question of social fear, but rather, satisfaction and self-confidence, which are not included in the formalization in the previous chapter. My research has indeed never gone far enough to include all human aspects. Its transcendental control has not yet made it instrumental enough to become entirely autonomous. A human overview is still needed as a feedback loop in the process. The question of authenticity alongside the need for human intervention arises here. But this feedback loop can be considered as just another process and be implemented within the concept itself by using machine learning, for instance. But this automatic characteristic embraces many factors which are outside any formalized process. For the moment, these believably identify the piece as a piece within a medium and a social context rather than pure code art. Many circumstances are needed as constraints and give life to the piece during its materialization.

Chapter 2

Non systematic algorithmic music

2.1 Introduction

In the previous chapters, an outline has been given to demonstrate an exploration of automatic generative concepts. This automatism is beautiful, but is still far from the actual realization of music. I consider external factors as determining constraints. I long have considered these constraints as distractions or diversions against my personal creative progress. But these restrictions have now become incorporated into my creative process and essential to my work. The workflow consists then in oscillations between the various generative methods described in the previous chapters and methods taking external constraints into account. There is the impression that I am continuously diverting the concept of a new work and then optimising the process accordingly. Constraints prevail in a computing sense and as driver. The frame defines a space, or a field, in which processes evolve. I am particularly enthusiastic about pure formalization and conceptualization. This chapter will demonstrate that I am also after a type of (ideal) naturalness, and instrumentalisation, that computational complexity can provide for both the concept itself and materialization. The fictional theory described earlier is part of other fictional phenomena that I attempt to practically place within socially complex projects. The next section is dedicated to explaining the realization of actual projects. The audience is far from expected to follow any sort of narration from the piece itself, a narrative can even emerge from overall randomness. Belief is then confronted with reality and generates frictions and interactions that are necessary for the piece to happen in real time and real space. The first confrontation is purely social and involves collaborators (musician, dancers, dramaturges, and so on) for works created in the past three years. Tangibility is where the second boundary lies. It involves the embodiment of listening with “active dancing”. It is also where the piece becomes an event. Spatialization naturally comes afterwards as another rendezvous with reality, where I propose solutions for the complete integration of the space within the composition. Another spatial integration consists of changing the acoustic space rather the sound itself.

Using several pragmatic experiences, I will describe the confrontation between the concepts (described in previous chapters) and a variety of encountered realities. The tensions arise in parallel and strongly influence the initial concept in a feedback loop becoming part of my workflow and eventually lead me to truly betray the initial rigorous systematic idea (a fantasy). This fantasy is one of many fictional sources of influence offered to the audience.

2.2 Confrontation with reality

Using several pragmatic experiences I explain here the influence external factors have on the formalist concepts presented in the first part of this text.

2.2.1 Social aspect (constraints and consequences)

I often collaborate with other people from other fields. I am forced to work with important constraints confronting the workflow described in the first part within specific contexts. Such conditions change the initial concept. Making a concept pragmatic changes the concept's characteristics.

Contextualised and narrated concepts



fig. 2.1 - *Songes et Métamorphoses* played at Théâtre National de l'Odéon in Paris in May 2017.

For me, the exhibition *The Universe and Art* at the Mori Art Museum, Tokyo, demonstrates how science and art works how important culture is in our vision of the universe. Our conception of the world in its entirety is tightly linked with society. The history of the search and tradition are important factors which can selectively forget, rejected, transformed or continued. Some Laurent Grasso, art pieces transgress strong esoteric symbolic aesthetics in an atheistic contemporary age. He, for instance, juxtaposes actual religious middle age paintings with stylistically similar but modern works. His work instantly delivers a sacred fiction, and can even imply a political opinion. The exposed historical context of his work allows a contrast with expectations and prescience (1.2.1). Mixed music, music with traditional instruments and live electronics, often gives me this impression. This is not a negative aspect, but rather a relational choice for the audience. Many artists transform their compositional machines into

interactive instruments for concerts, installations and so on. Others explore the possible artistic and technical relations between live instruments and electronics. Others declared loudspeakers as instruments. Finally others do not think at all about the issue and leave the audience to decide for itself. This last approach is probably not the most technically interesting, but from afar, the best solution for dealing with the social impact of computer music.

Dance music, for instance, does not take any traditional paradigms into consideration and instead proposes a physical active listening with its own cultural inscriptions. Aside from the music itself, the atmosphere inside some clubs is enough for visitors to be transported. But this archetype has become part of a tradition and is far from being new. Art cannot really get rid of culture and history by definition. All possible pasts, accepted or rejected, are inevitably elements of a narrative. I plan to add this fundamental element to my concepts. I have an increasing desire to abstractly socialize my work, if not politicize it (2.2.1).

Bernd Alois Zimmermann's *Requiem Für Einen Jungen Dichter* is an important example in this regard. The piece for three choirs includes the Latin liturgical *Mass for the Dead* and literary, philosophical, religious and political texts, related to politics and the history of mind during the composer's life. Subjects like simultaneity, past, present and future are here not the physical ones but rather considered with a human, a historical perspective:

"Everything takes place simultaneously in that pluralistic 'spherical form of time' which was Zimmermann's philosophical and compositional aesthetic model: 'The observation of the past, present and future is a question of aspect. The observer sits in the centre of a sphere surrounded by time, a continuum; what he observes depends on his perspective, because whatever happens now is already the past in the moment of its occurrence, whatever we do – we determine the future, and the future has already determined the past – the tempora are interchangeable.'"

Program note for the 2009 concert *Peter Eötvös conducts Zimmermann's*

Requiem for a Young Poet performed by the Berliner Philharmoniker.

For me, the fact I barely have links with social reality sometimes makes my work more difficult to confront it with nature; and human nature. As for dance, tangibility sometimes creates difficult, but necessary constraints. An ultimate confrontation happens when collaborating with naturalist people interfering my aesthetics with figurative symbols (2.2.1). Stream of narrative consequently takes many forms that I am forced to integrate within my work. The coherent outcome of what I build has to find its social and artistic position between mod-

erate or radical. And this is a decision I always take differently for each project. *Joyeux Animaux de la Misère* and *Songes et Métamorphoses* were experiences for that concern in the recent years within the duration of the PhD.

My limited links to social reality, occasionally makes my work more difficult when confronted with nature; especially human nature. As for dance, tangibility sometimes creates difficult but necessary constraints. An ultimate confrontation happens when collaborating with naturalist people interfering with my aesthetics of figurative symbols (2.2.1). The stream of narration consequently takes many forms that I am forced to integrate within my work. The coherent outcome of what I build has to situate itself between moderate or radical social and artistic positions. And this is a decision I always make differently depending on each project. Working on *Joyeux Animaux de la Misère* and *Songes et Métamorphoses* in 2016 was an experience in which these personal concerns were at the forefront.



fig. 2.2 - *Master Rock* is about workers who, in the late 1950s, built the dam at the Cruachan Power Station in Scotland.

Social and political emphasis

Recently, I have personally been involved in several situations where the audience became involved in the narrative process of the piece. The “multimedia” theater piece *Aucun Homme N’est Une Isle* for which I did the music in 2013 was a show for children. The contact with a new kind of audience surprised me. I was, for instance, commissioned to write a piece for the 50th anniversary of the inauguration of the Ben Cruachan dam in Scotland. *Master Rock* literally tells the story of Irish workers who risked their lives building this underground cathedral. Recorded and performed inside a power station deep within the mountain, the piece is both a performance and a radiophonic piece piece. It was commissioned by Artangel and the BBC Radio 4.

In the early 1960's the workers, "tunnel tigers", blasted their way through granite to hollow out a vast hall of the new power station. The place was opened by Queen Elizabeth II in October 1965 (fig. 2.2). Maria Fusco wrote a "poetic novel", *Master Rock*, relating the story of these mostly Irish workers who risked their lives and then were not invited to the opening.



fig. 2.3 - *Joyeux Animaux de la Misère* setup.

Another recent creation with similar social and political concerns is *Joyeux Animaux de la Misère* premiered in Paris in June 2014 (fig. 2.3). Compared with *Master Rock*, social and political emphasis are not within the content of the piece, but rather the situation in which the work was created.

Pierre Guyotat wrote a new book for Gallimard containing rich and well written explicit gore text. Some extracts are read by Stanislas Nordey during the performance. Concepts described in the first part of this thesis are then socially confronted to the artistic politics and artistic directions within institutions. Historical background and its consequent ways of working are important in how I can deal with my ideas.

Some other computer music composers also involve politics in their work, or at least a social aspect. *Politiken der Frequenz* by Marcus Schmickler and Julian Rohrer is a good example of abstract, but rational, theory-fiction.

Collaborative works leading to a layered complexity of fricative fictions



fig. 2.4 - Discussion for *Master Rock* where the space is so noisy discussing requires to be close one from another.

Descriptions of works such as *Master Rock* and *Joyeux Animaux de la Misère* demonstrate how cultural aspects were a prominent part of the compositional process (2.2.1). There are also constructive constraints in collaborations with other fields and judgments. Every project is a different adventure, a position for everybody has to be defined, or naturally defines itself. This is especially the case for the musician as an artist. Artist, not within some social artistic condition, but rather as a collaborator in the actual content (beyond music).

Handling a complex object like the big theater piece *Songes et Métamorphoses* obviously concerns the relation between sound design and music composition. Many directors and choreographers expect to work with “sound creators” whose input is later free to transgress. This is for me not a question. A piece I judge as “good” has to work on all aspects, in all dimensions. There is the need for a composer, as an artist, to create and grow in isolation. This person has to be able to make music in complex situations while keeping the needed space for freedom and creativity (1.3.3).

I personally found that a trust between collaborators can be either done with pedagogy or by advocating for the good of the project. I had extremely long discussions and exchanges with the collaborators of *Songes et Métamorphoses*. These exchanges became an interesting part of the work. But I admit, for this work, I sometimes used my trusted expertise and personal style to make musical decisions for good of the piece, without regard for my collaborators

input (fig. 2.19). This is a view from an artist who nevertheless needs to implement dramaturgy, duration and many other factors in his compositional process. This is totally a question of orchestration from both the sonic and the dramaturgical points of views. These choices have a drastic influence on the resulting aesthetics (fig. 2.5). Interesting strategies that can be implemented within my compositional system are:

- The first strategy includes more collaborators and focuses on the balance of the piece in its entirety. The amount of music and its moments of rising need to be openly discussed, or secretly decided, with other artists of the project who are aware of the dramaturgy of the text. Silence can be defined by its surrounding music beforehand and afterwards. Or it can simply be a silence with no context. I often think of Claude Debussy and his relation with silence which has a link with minimalism. Pierre Boulez talks about it in *Stocktakings from an Apprenticeship* (Boulez, 1991):

“Debussy rejects any hierarchy which is not implied in the musical instant. With him, often, musical time changes its meaning, especially in the later works. So the act of creating his own technique, creating his own vocabulary, creating his own form, leads him to overturn ideas which had hitherto remained eminently static: the fluid and instantaneous irrupted into music; and not merely the impression of the instantaneous, the fugitive, to which some have reduced it; but a genuinely irreversible, relative conception of musical time, and of the musical universe more generally. For the organization of sound, this conception translates into a rejection of existing harmonic hierarchies as the sole property of musical reality; relations between objects are established by context, according to variable functions.”
Pierre Boulez, *Stocktakings from an Apprenticeship* (Boulez, 1991).

- The second strategy consists of playing on top of the text with the positive or negative question of interference. It is possible to play with the dynamics of the sounds. For instance, voice rhythms can create musical counterpoints and accents. This can be formalized then automated with envelope followers or speech recognition systems.
- As a third choice, it is also possible to create sounds with a different tessitura from the voice. This is very useful for a particular style of electronic music where most of the spectrum is located in just high and low frequency areas. I personally like bass frequencies for their power and extremely high frequencies for their perceptual precision and beauty.

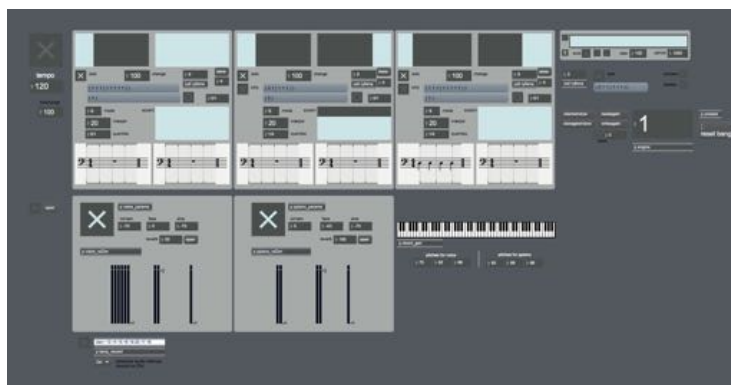


fig. 2.5 - Main Max interface for the creation of *Songes et Métamorphoses*. Even though rehearsals are extremely long, there is absolutely no time nor space for making sound during that period. I need to program on the fly and play music before it is too late to keep anything. The generative system is then very useful to build material and keep a coherence all over the piece. This composition workflow itself becomes my instrument as much as if I was using sound generators from analogue machines. I am instead using both symbols and signal.

- A fourth strategy consists of composing material that is closely synchronized with what happens on stage. This is a common strategy for music-theater because it is the easiest possible proposition. It is also what a stage director wants if there has been no communication or interest in coordinating the theatrical concerns with musical concerns. There are nevertheless very rich directions to explore when trying to stay as figurative or even naturalist as possible (2.3.1). Composing from initial staged sounds can be a very good starting point for a whole piece. This is what I have done with *La Nuit Tombe*, a previous theater piece for which I composed the music. For *Joyeux Animaux de la Misère*, the text has no meaning that would allow such figuration or even symbols.

There is the possibility to use real-time transformations on the voice: I am fond of Psola synthesis for instance.¹ I used both ambisonics and WFS systems as much as the hall was capable of supporting (fig. 2.6). I already used this WFS for a dance show called *Night Light* in 2011 (2.2.2). This allows a precise positioning and play with a mix between traditional spatialization and envelope spatialization (1.3.3).

¹Psola synthesis is a kind of controlled granular synthesis from the early 2000s when it became possible to get a clean fundamental frequency from voiced sounds; the Holy Grail for signal processing.



fig. 2.6 - *WFS* system in the Espro modular concert hall at Ircam.

- A fifth choice consists of marking time with sound events short enough, they can be heard without always interfering with the text. In that situation timbre does not matter so much. It is more question of events, onsets, with stage and speech. I found this technique very efficient because it can do everything; it can oscillate between accompaniment of the speech and a total distortion of understanding. When sounds are very short, the result stays purely musical and is totally independent from theatrical questions. It can nevertheless be used to cut or accent stage events. But when sounds are longer or when the density of sounds increases, time scale changes and the musical result is more questioned with the stage.

Return, feedback into systems composition

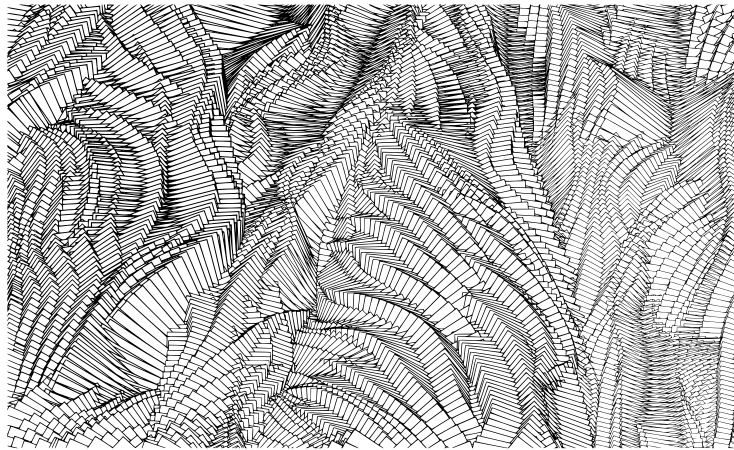


fig. 2.7 - Weaving of pseudo-periodic layers. This picture is an early model of a Fresnel lens to be CNC cut and used in a future project.

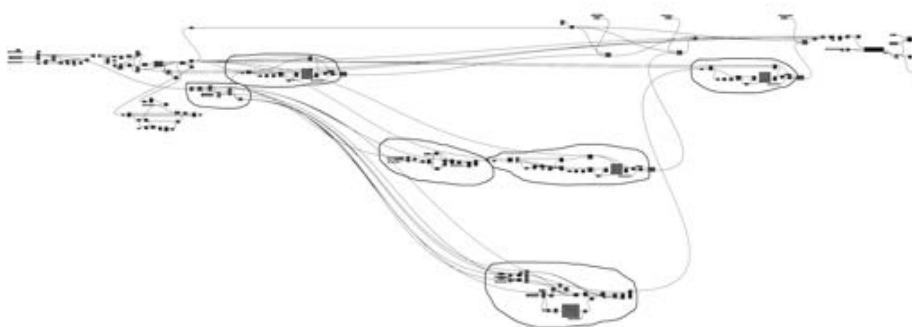


fig. 2.8 - Grasshopper Rhinoceros 3d patch used to generate interleaved parallelepipeds in figure fig. 2.7. This patch is also used for experimenting with new spectra for *Master Rock* and *Forma* depending on external factors. This patch uses the *Lunchbox* and *Galapagos* libraries for optimising the overall form according to a set of constraints. The patch is as messy as it should be in an efficient production situation.

Master Rock and *Forma* both need to adapt themselves according to external factors. *Master Rock* was composed before I could actually make sound inside the mountain. The complexity and price for that specific space only allowed the piece to be run, and radio broadcast, as soon as speakers were set.

Last minute external factors deal with characteristics like specific scenic moments, new fixed durations etc. They can depend on stage or light elements that cannot be formalized before-wards. Simply rescaling, or remapping, all previously chosen parameters one by one would be the same as composing a new piece from the beginning, at the last minute. The whole system is so intricate that changing one parameter would also change the rest of the piece. I believe this is a problem of non-linear mapping. . .

Experiments with the *Lunchbox* and *Galapagos* libraries from Rhinoceros 3d were made before rehearsals. Time is the easiest external element that can affect the piece. So I experimented with that as a starting point. I added, in the Rhino code, new timing constraints into onsets previously imported from the Max patch (2.2.2). I could then get several versions of forms that would best fit the needs; as shown in figure fig. 2.7.

optimising a form after the initial creative processes is an act of interpretation before the performance (1.2.2). The algorithm within Max builds an initial score that will afterwards be re-modeled by Rhinoceros 3d. As described earlier in 1.4.1, the initial score becomes the initial spark of the whole system: it becomes the very beginning where its deep origination does not matter. This is a dead-end in the tree of the dynamic system because there is no feedback and it cannot adjust dynamically (2.2.1). This could therefore be anything like noise or any kind of data. It would not necessarily be a complex and crafted process. So the implementation of such optimisation remains difficult because

there needs to be a clear systemic formalization of those external circumstances; human factors for instance.

I believe this *loophole* has a close link with negentropy, the negation of entropy described here 1.4.3. There may always be the need for a communication, probably a *confrontation*, between the inner system and external factors; between composed though experiment and Nature. This is the reason why I am interested in artificial Nature and what it questions between *matter* and *information* (in case they are not considered as the same).

2.2.2 Sound Spatialization

Sound spatialization must conform to the building in which the piece is being presented. Utilizing a variety of sound spatialization techniques, I constructively work in the conditions of real spaces and implement conditions of virtual spaces in my creative compositional process.

Constraints from spatialization



fig. 2.9 - Tests for *Master Rock* in autumn 2015. This point of view shows how deep the performance space is and all its acoustic possibilities one mile inside the mountain.

Spatial processes set in real-space and real-time My work with geometric spaces is described in the previous chapter, 1.3.3, where I also associate spatial topology with compositional processes. The space I am describing here is architectural. The physical space can be linked to larger creative concepts, but ideas around spatialization are connected directly to the architecture of the building, the envelope where the piece is presented. This is why I like organ music. For me, it is a given that concert hall changes the perception of music; both psychologically and perceptively, visually and aurally. The architectural building then has no choice but to be tightly linked with composition if one wants to have control over what the audience receives for interpretation (1.2.2). Real space becomes an impulse for inspiration and provides a habitat for my music to thrive (2.2). Spatialization is an essential component of my sonic fabrications.

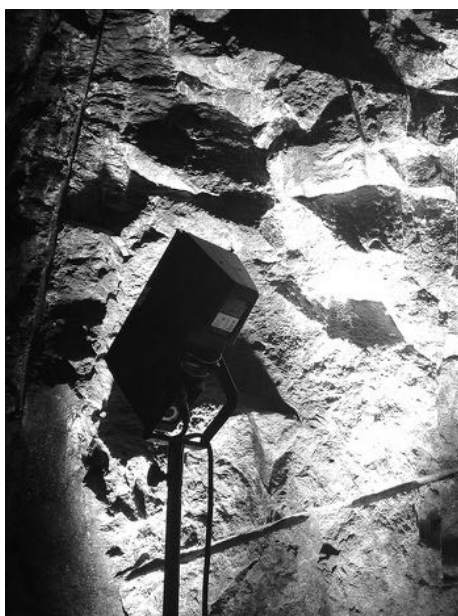


fig. 2.10 - d&b speakers sending strong attacks, almost dirac impulses, towards granite walls

In the past I attempted to remove as much room as possible from the physical space in which I was working and replace it with my own controlled spatialization. Curtains, position of speakers, everything was designed to gently remove the characteristics of a hall, only keeping its beautiful natural reverberation. This character of a beautiful reverberation influences the style of bands like Laibach or the 2017's Belief Defect who need large spaces to be effective. But these setups were usually permanent, unless the space or the stage could change or move (variable acoustics, specific stage design etc.). Outside of classical music conditions, other external factors do not permit using the hall in such a way.

This technique of removal is a negation of the space itself, its context is erased.

More recently, I have used artificial reverberation together with the real reverberation of the space without trying to attenuate or remove the natural response of the room. I instead often use impulse responses (3d or not) specific to each space and piece. I am mostly using the *Spat* from Ircam. I can sometimes use the one from *HISSTools* from Alex Harker and Pierre Alexandre Tremblay when I need to process impulse responses (Harker and Tremblay, 2012). I conceive convolution according to the hall where the piece is played and, moreover, depending on rhythms generated for the pieces and also by the space. I created specific impulse responses for a specific dramaturgic element in *Songes et Métamorphoses* (2.3.1). I am fond of early reflections with fractal characteristics as described earlier (1.4.2). This spatialization technique using impulses is yet another description of my stylistic envelope spatialization technique found in many of my compositions. The technique provides the pointillism I desire.



fig. 2.11 - The Cruachan Power station. Performances happen one mile underneath.

There is neither a sweet-spot, nor means to mask speaker positions as one would normally do with holographic sounds set-ups. Responses to percussive sounds, and speaker positions, both give speakers the personality of an instrument.² This spatialization concept has some similarities with acousmatic diffusion techniques besides the fact it is mostly about impulse response rather equalization.

Master Rock was performed inside the mountain one mile below the dam. The granite machine room is several hundred of meter long and also tenths of meters high; it is enormously resonant. I had no choice but to use the space as a body exited by powerful and sharp envelopes. I asked to precisely set some speakers against walls in order to play with resonance and first reflections. The calculated first reflections would generate rhythms with the same concept

²I actually cheat using a different equalization and delay for each speaker. This also enhances the impression of movement.

explained in the first part of this text (1.4).³ The size of this troglodyte cathedral allowed me to directly connect my generative rhythmic processes with the actual space. I had enough power and distance to get delays long enough to perceive displacements. Sharp attacks and variable durations resulted in oscillations between granular synthesis textures and rhythmic patterns; the perceptive continuum described earlier (1.4.1). On a poetic level, the impulsive sounds fit perfectly with Maria Fusco's book imaging the power of explosive blasts used to break the granite.

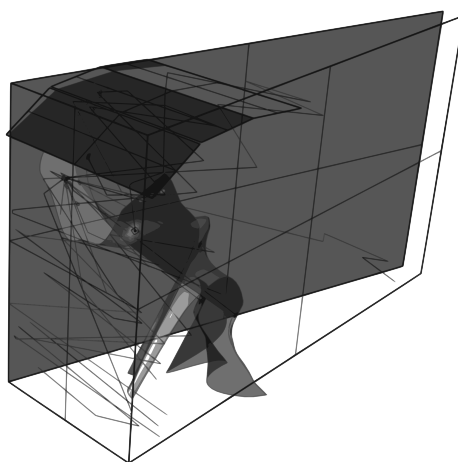


fig. 2.12 - Sonic rays are made of short rhythmic bursts that hit a large acoustic panel. They can either go through holes (rings in the picture) or be reflected with a specific angle (2.2.2).

Fabricated spatialization When moving inside the very noisy and very large machine hall of the Cruachan Power station, rhythmic attacks directed against the granite walls create an acoustic space people can walk in. Even with a continuum of impulse trains, one hears interpolated rhythms depending on one's position in the space (fig. 2.10). This technique of reflection worked very well. This architectural space truly became materialized music, an object (1.2).

The ideas behind the neo-futurist movement aligns with my utopian thoughts about music. I believe it is an occasion to continue the exploration between music and architecture. Alvin Lucier is an artist dealing with similar questions in his 1969 work, *I Am Sitting in a Room* is an iconic example (Lucier, 2012).

I also have the idea of a step further on that concept of space. I would like to compose with an inverse situation: the music would be almost entirely fixed and continuous, projected using hyper-directional speakers against acoustic panels that would delay reflected sounds. To be effective, the right speaker positioning and target points for specific speakers need to be calculated precisely, as well as

³Using a mix of Rhinoceros 3d and Jtol.

utilizing the right form of acoustic panel.⁴

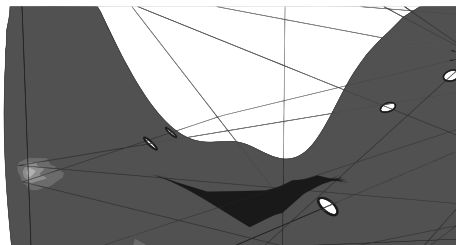


fig. 2.13 - Ray-casting of sonic rays using an array of hyper-directional speakers. These speakers project composed short impulses that are reflected by walls (audio-mapping). An additional form is build and precisely set inside the building. This permits the control of impulse reflections depending on the position of the listener. The composition is the sonic piece and the form. The final piece has parallel time-lines depending on the position in the hall.

This is exactly what Frei Otto and Lars Spuybroek were achieving visually; using minimal surfaces and generating what I called structure of vagueness (1.3.2, 1.4.2). This is the inverse of room acoustics, where the building's structure inscribes the optimum form for generating a particular rhythm based on first reflections. The Finite-difference time-domain method works well for calculating target meshes and acoustic diffraction. I also see it as the inverse of sonic ray tracing (1.2.1).

This idea of inverted sonic ray tracing is for me the ultimate spatial and material constrain I can totally implement as part of a compositional concept: true spatial composition and synthesis using a continuum between micro and macro forms. I recently coded non-standard forms using genetic algorithms in Rhinoceros 3d (1.2.2). The experiment remains virtual until I get the opportunity to be involved with actual architects. I describe the idea in more details in 2.2.1.

⁴The first difficulty that has to be considered is the limitation for the ear to hear beyond roughly 20 Hz. The body can feel any low frequency if loud enough. But even with a large space, the audience will hear synthesis rather discrete elements. I should then use the technique described earlier to make discrete elements from synthesis (1.4).

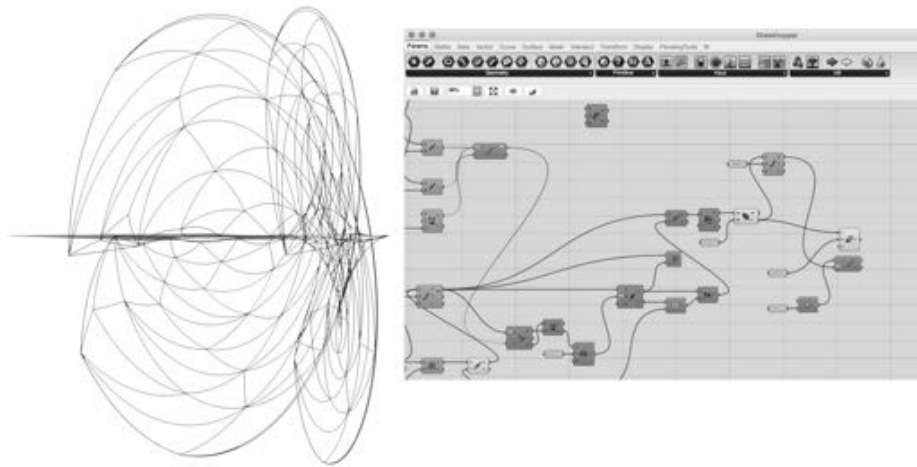


fig. 2.14 - Material spatialization: I am willing to generate spatial rhythms. A voronoi tiling allows me to generate a non orthogonal grid. Each node is randomly positioned. The 3d-printer stops at every node; that generates rhythms.. Each segment has the same duration for printing because it has the same length. Equidistances are calculated either on the curves themselves or a projection to one of the axis.

Return, feedback into systems composition



fig. 2.15 - Readers positioned for the reading of Maria Fusco text for *Master Rock* deep inside the mountain, underneath the Scottish Power's Cruachan Power Station dam.

We have seen that *Master Rock* was using envelope spatialization (1.3.3, 2.2.2). Sound positions are set by a simple rhythmic technique I used in most of the pieces presented in this text. My interest oscillates between for some sort of minimalism and new complexity approaches. This also affects in spatialization.

The idea first consists of choosing initial phrases for each parallel engine. Their choice depends on the needs. I choose very close phrases, or the same ones, if I want to play with phrases slowly delaying one another. I chose a series of simple phrases that fit if I want to get more rhythmic ideas. In that case,

phrases need to have one or several common onsets so that the poly-rhythmic result does not diverge too much too quickly. Playing with a slow phasing is often the right choice for sound spatialization.

All voices are played side by side with their own independent evolution generating more and more complexity over time; exactly like a cellular automata iteration after iteration. An audio and spatial texture are eventually made thanks to events getting very close to each-other; sometimes up to the level of audio sample. The resulting sensation varies from discreet elements, to something messy, until a granular synthesis texture. Live was used when grains were distant enough and the CSound~external within Max for cases with closer sounds.⁵

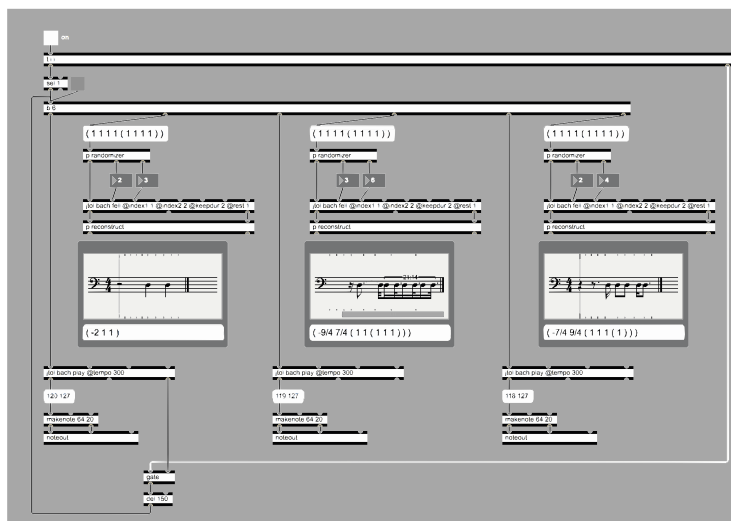
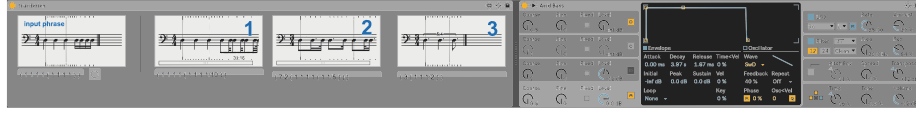


fig. 2.16 - This *jtol.bach.fell help* Max patch is a result of the loop system used for spatialization in *Master Rock*. It takes a rhythmic phrase and only loops a part of it. The difference with Philip Glass and Mark Fell is the possibility to use irrational durations. Those durations are also part of the output rhythmic tree and can then later be transformed.

These layers can be left alone or re-synchronized when needed. The system in *Master Rock* allows an iterative come-back of phases to their initial states. This never really worked properly and it is definitely something I will have to work on in the near future. Re-synchronization, convergence, can otherwise be done at each end of the longest, or shortest, measure of all voices. The fact I am using a tree structure allows me to have equal, or entire ratios, between voices. Unfortunately for *Master Rock*, I did not have the time to implement a control with nested level branches yet; unlike *Songes et Métamorphoses*.

⁵I did not use *gen~* because I wanted to be able to run it in off-line; outside of Max.

fig. 2.17 - Max4Live device generating only three voices from *jtol.bach.fell*.

```

1  /*--- */
2  opcode RandomWalkK, k, kiii
3
4  kstep, imin, imax, iseed      xin
5
6  k1  init (imin + imax) * 0.5
7  k2  rnd31 kstep, 0, iseed
8  k3  = k1 + k2
9  k1  = ((k3 < imin) || (k3 > imax)) ? k1 - k2 : k3
10
11  xout      k1
12  endop
13  /*--- */
14
15  /*--- */
16  opcode RandomWalkKdyn, k, kkkki
17
18  kstep, kmin, kmax, kkcount, iseed      xin
19
20  kkcount      init      0
21
22  if kkcount = 0 then
23      k1  = (kmin + kmax) * 0.5
24      k2  rnd31      kstep, 0, iseed
25      k3  = k1 + k2
26      k1  = ((k3 < kmin) || (k3 > kmax)) ? k1 - k2 : k3
27  endif
28  kkcount = (kkcount + 1) % kkcount
29
30  xout      k1
31  endop
32  /*--- */
33
34  /*--- */
35  ; Scale 1: Equal-tempered Twelve tones (12 steps per octave)
36  giHalfTones      ftgen      1, 0, -12, -2, 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100
37  ; Scale 2: third-tones (18 steps per octave)
38  giThirTones      ftgen      2, 0, -18, -2, 0, 66.67, 133.33, 200, 266.67, 333.33, 400, 466.67, 533.33, 600,
39  ↪ 666.67, 733.33, 800, 866.67, 933.33, 1000, 1066.67, 1133.33
40  ; Scale 3: Quarter Tones (24 steps per octave)
41  giQuarTones      ftgen      3, 0, -24, -2, 0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650,
42  ↪ 700, 750, 800, 850, 900, 950, 1000, 1050, 1100, 1150
43  ; Scale 4: Indian Srtuti (22 steps per octave)
44  giSrtuti         ftgen      4, 0, -22, -2, 0, 90, 112, 182, 204, 294, 316, 386, 408, 498, 520, 490, 610, 702,
45  ↪ 792, 814, 884, 906, 996, 1018, 1088, 1110
46
47  gidura           ftgen      0, 0, -100, 2, 1/5, 1/3, 1/3, 1/3, 1/10, 2/3, 1/10, 2/3, 1/5, 1/5, 1/5, 1/5
48  gilens           ftgen      0, 0, -100, -17, 0, 0.4, 85, 1
49  giwave           ftgen      0, 0, 4096, 10, 1, 0, 0, 0, 0.05
50  gisine           ftgen      0, 0, 4096, 10, 1
51  /*--- */

```

fig. 2.18 - Extract of the CSound instruments used for *Master Rock*. CSound was used for non-realtime parts in the case onsets were very close from eachother.

2.2.3 Transition

We saw a number of encountered realities where, and when, my pieces were materialized. These corporealities are not always felt as a negative confrontation or constraint. They are also an engine which eventually becomes part of the composition process itself. Back-and-forth tweaks between the programming part and practical elements sometimes make modifications that can totally change both aspects.

2.3 Fictional concept

I have attempted to propose an arbitrary and unified thought in which patterns can freely follow the narration of an imaginative construction. The initial concept is betrayed, but its consistency still remains. This sometimes happens in conjunction with other narrations, the dramaturgy and so on. That it exists from the audience's point of view allows for a certain freedom in its creation, as much as complete randomness, since what matters is a believed entropy.

2.3.1 Fictional and artificial nature

This belief springs from timelines, spatial and social positions. I want the listener to have an active listening as if he were reading a score with a sense of narration. I often work with writers, theater and so on. Artificial nature in the poetic sense.

Streams of narrative added to composition complexity



fig. 2.19 - *Songes et Métamorphoses* which has a strong musical part, was created at the National theater La Comédie de Reims in October 2016. The piece lasts about 4h45 including an intermission. 18 actors, children, one dog, two pop singers, several stages.

The piece *Songes et Métamorphoses* is a theater piece, directed by Guillaume Vincent is 4 hours and 45 minutes long. It was created in October 2016. I was commissioned by Ircam-Centre Pompidou to create the strong musical component. It is a homage to the power of imagination. It is a kaleidoscopic contemporary version of Ovid's *Metamorphoses* followed by William Shakespeare's *A Midsummer Night's Dream*.

The structure of the piece was initially inspired by Benjamin Britten's opera *A Midsummer Night's Dream*. The piece has two "pop music" singers whose songs influenced the opera to resemble the form of a Broadway musical. Some other parts are also inspired by Felix Mendelssohn's *A Midsummer Night's Dream*. The whole piece is then a succession of different styles followed by a high-point in Elizabethan comedy. The combination of the two plays provides a tension in the work between a theater waiting to be done, theater that has been done, with real life acting as a foil. Guillaume Vincent also adds elements from the real lives of the entire production team. The plot is even more intricate because William Shakespeare added the schizophrenia of using three works tackled by "three different directors" to tell two different intrigues. The length, the number of actors, the amount of effects and the enormous stage all contribute to conveying the piece to a monumental and complex machinery. This complexity had already been implemented the same production team for previous pieces, Frank Wedekind's *L'éveil du Printemps*, *La Nuit Tombe* and *Mimi*.

The historical background is so present in the production that I could not avoid including elements of both Felix Mendelssohn's and Benjamin Britten's operas of *A Midsummer Night's Dream*. I left these tonal parts/references of the work for the "pop" singers to perform. William Shakespeare's universe became part of the constraint for the music.

This is always a long epic adventure; as much as the artistic result would be. The life of the project, with the production team, imposing constraints on each other, in addition to the constraints of the actual piece form one single complex system. Its coherence is often not questioned and this became the overriding characteristic of the final piece (2.3.1). Narration has no other choice but to be implemented within the musical concepts in the form of a stream.

Surreal projection: position for narrating vs playing

Songes et Métamorphoses elaborates on musical connections between playing and acting. It indeed merges my neo-futurist synthetic music into figurative narrated elements. This is nevertheless not in opposition with poetic artificial nature and baroque described earlier (1.2.2).

The merging of genres into a post-modernist piece creates a strange loop



fig. 2.1 - *Master Rock* and *Joyeux Animaux de la Misère* written and edited at the occasion of their performances.

between reality and the concept where reality figures into the concept and vice versa. It is all illusion where everything is fictive, nothing is generalized, and there is no actual truth (1.4.2). Douglas Hofstadter creates a similar situation in *Gödel, Escher, Bach: An Eternal Golden Braid* (Hofstadter, 1979). There are also here again similarities with Nick Bostrom’s simulation hypothesis (40). But I have no intention to be Cartesian and prove any kind of reality. My motive is rather to present a concept that can freely be discovered and openly explored (1.2.2). My own cultural background prohibits me from being completely incoherent, in this regard, it becomes difficult to label a piece generated from complete randomness a composition. I require a synthetic realism, which I refer to as a “computational universe” (fig. 2.27).

This reality is a reality of thought and nothing else. It is a piece of art and not another being. The Speculative Realism school aligns more with my thoughts in these instances. I imagine this line of thinking is linked with the notion of the information age and the abundance of fantasies about artificial intelligence.

The direct artistic consequence can be augmented reality in which an artificial world is mixed with reality. I consider 1960s raster architectures from Otto Beckmann as early augmented reality pieces. Both reality and virtual parts merge and have the motive of being imaginary shadows of some impossible form. More recently, Antoine de Schuyter masks geometric patterns onto beautiful abstract, almost surrealist landscapes as one would find in Andrei Tarkovsky’s *Stalker* (Tarkovsky, 1989).⁶

⁶ Antoine de Schuyter did videos for Plaid, Kangding Ray, Funckarma or Venetian Snares. See also Boris Labbé’s *stretc.hed* artificial mountains accompanying the music of Daniele Ghisi in 2016.

Simulation as an illusion

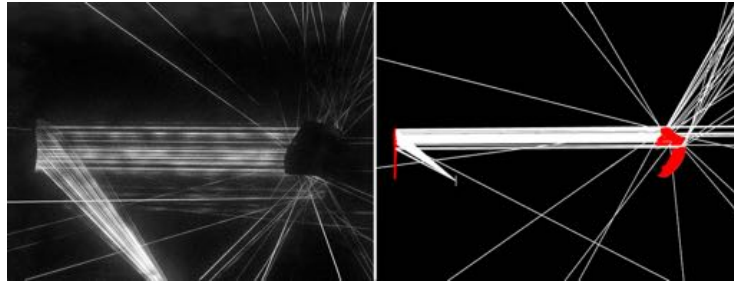


fig. 2.20 - Simulation of my performative installation at the *Greatbatch pavilion*. The left side is the rendering of a white laser against two very complex mirrors. The right side is a simulation of it. I here used the Maxwell ray tracing renderer and Rhinoceros 3d for the design. Both picture are synthetic.

I had the opportunity to attend readings of the totality of William Shakespeare's *Henry V*, *Henry VI* and *A Midsummer Night's Dream* by actors around a table during rehearsals. They were given two choices. They would either act as if they were on stage or they would read in a declarative way as if they were telling a story. In other words, they have the choice to live the play, be within characters, or stay outside. If they read it as a story, they are intended to have an overview of the entirety and thus have an overall control of the time of the piece. This time does not actually exist as discussed in 1.2.3. One difference between actors and musicians may reside in declaring can narrate the content using the same medium while playing cannot, unless the musician starts talking. Computer music has the same impracticality unless a screen is used to show a description of the concept. The telling needs to be outside the piece unless it is based on text or voice. Symbolism spring from this idea. The piece can resemble something the audience or the visitor would recognize and associate with; like symbols. These can in some cases be abstract like signs organized by grammars (1.4.3). But the need for association naturally leads to figures derived from real object sources as for *figurative art*. The piece can then legitimately tell something if there is an illusion of reality: a certain *naturalism*. This can eventually lead to narrative; the story read in a declarative way rather being played like an instrument. It is a silent movie with a human presence. Anthropomorphism is very important for humans to project themselves into a story. This is why theater involves so many humans in order to provide an accessible simulation for the audience. This simulation actually played or narrated is an illusion.

Physical modeling

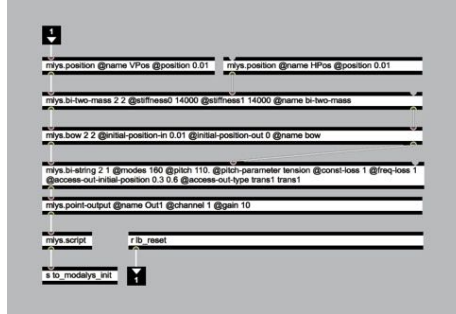


fig. 2.21 - Max patch generating a script for the modalys~ external. I widely used this bi-string model for *Netivot* because of its distortions; “natural and beyond”. Such distortion is made by pressing the bow strongly to the string, changing the physical characteristic of the string, and placing the microphone at an edge; like the bridge.

Physical model synthesis simulates a physical source of sound. It offers the possibility to reach sounds close to real physics and further transform them. It perfectly follows the ideas of naturalism.

I was invited to do the electronics for the quartet called *Netivot*. This David Felder’s piece was created by the Arditti String Quartet in June 2016. JT Rinker was also in the project. It used modal physical synthesis with Modalys in order to get frotté and other peculiar and fragile harmonic distortions. Those frottés have a similitude with what thick paint impasto technique would do onto canvas.

In one scene of *Songes et Métamorphoses*, there is a party with imaginary animals in a forest. I used a model of tube with distorted blowing sometimes giving the impression somebody would play didgeridoo.⁷

```

1  execute new()
2  execute set_precision('float')
3  execute bi-two-mass_c1 = make_controller('DYNAMIC',1,-1,0.01,'bi-two-mass@small-mass')
4  execute bi-two-mass_c2 = make_controller('DYNAMIC',1,-1,14000,'bi-two-mass@stiffness0')
5  execute bi-two-mass = make_object('bi-two-mass',bi-two-mass_c1,bi-two-mass_c2,bi-two-mass_c3,bi-two-mass_c4,bi-two-mass_c5,bi-
↳ -two-mass_c6,bi-two-mass_c7,bi-two-mass_c8)
6  BiString_c1 = make_controller('DYNAMIC',1,-1,160,'BiString@modes')
7  execute BiString_c2 = make_controller('DYNAMIC',1,-1,1,'BiString@length')
8  execute BiString_c3 = make_controller('DYNAMIC',1,-1,94.66,'BiString@tension')
9  execute BiString_c4 = make_controller('DYNAMIC',2,-1,[1.000000 9.000000],'BiString@young')
10 execute BiString_c5 = make_controller('DYNAMIC',1,-1,1,'BiString@const-loss')
11 execute BiString =
↳ make_object('bi-string',BiString_c1,BiString_c2,BiString_c3,BiString_c4,BiString_c5,BiString_c6,BiString_c7,BiString_c8)
12 execute BiString_pitch = make_controller('DYNAMIC',1,-1,110.000000,'BiString@pitch')
13 execute set_pitch(BiString,'tension',BiString_pitch)
14 execute BiString_pos_in_1 = make_controller('DYNAMIC',1,-1,[0.050000],'BiString@access-in-1-position')
15 execute BiString_access_in_1 = make_access(BiString,BiString_pos_in_1,'trans0')
16 execute
17 execute bow = make_connection('BOW',bi-two-mass_access_out_1,bi-two-mass_access_out_2,0.010000,BiString_access_in_1,BiString_
↳ access_in_2,0.000000,bow_c1,bow_c2)

```

fig. 2.22 - Short extract of the Modalys script used for *Songes et Métamorphoses*.

⁷The tube sound would have been different using a waveguide synthesis. Articulations of blown air (filtered noise in my case) is different when being distorted.

Oneiric and kitsch



fig. 2.23 - *Echo and Narcissus* from John William Waterhouse in 1903.

Songes et Métamorphoses uses “pop singers” for some parts. Besides the beautiful re-arrangement for the opening of some sections, I squeezed them using psola synthesis. A sdif file allows me re-synthesize sounds with separated pitches, speeds, vibratos, tremolos and for several voices. I can recreate both the oneiric and kitsch sides of classic voice singing. But I can also tweak parameters and diverge into another reality.

I did the same tweaks for the purely visual piece *Kapteyn b* (fig. 2.27). It is a large, high resolution print from 2015. A Julia set draws the plane with recursive curves. The piece looks very much like a *terrain heightmap* of a real landscape excepted that it is a composed procedural terrain using fractals (fig. 2.27). The piece looks kitsch because it is full of historical background and landmarks. Everybody knows the Julia set and Benoit Mandelbrot’s sets. But the way I change them makes a tiny difference that brings a subtlety at the very limit between something one has seen before and something unique. This limit is also the edge of chaos and has a form of minimalism (1.4.2).

I also play with same recognizable cultural patterns in *Master Rock* or some part of *Proxima b1*. I use minimalistic forms repeated, or iterated, so many times they become complex. There is a far resemblance with Philip Glass’s repetitive *Einstein on the Beach* (1.4.2). The kitsch that interests me is also the Richard Wagner’s *Gesamtkunstwerk* described earlier, 1.2.1. The dramatic dominant aesthetic control, giving an impressive sense of greatness. I am, for instance, thinking of Pan Sonic, Atom tm or Ben Frost in their own respective ways. Ulf Langheinrich and Kurt Hentschläger from the duo Granular-Synthesis make, together or alone, impressive pieces using huge large scale pieces. They touch the audience with Pavlovian stimuli. These reflexes lead to a kitsch aesthetics that is so well composed their pieces provide highly valuable content.

Return, feedback into systems composition



fig. 2.24 - Part of the Live session for the first part of *Songes et Métamorphoses* (the *Songes* part). There are a hundreds of events; some are musical, others are theater sound effects. Some tracks use homemade Max4Live devices for specific effects on voices and microphones hidden within the stage set.



fig. 2.25 - *Songes et Métamorphoses*. Emilie Incerti Formentini in *Procne*. This scene is very heavy both for the music and the dramaturgy. I here use clusters of 1/16th-tones chords eventually converging towards one single note after 20 minutes.

As seen before, *Songes et Métamorphoses* is a very oneiric piece (2.3.1). Some aesthetic choices surely made it; for instance the use of pop singers singing beautiful music I composed for the occasion. But there is also a link with my

personal process and inspirations, described in the first part of this text which are not obviously as beautiful. One specific part of Ovid's *Métamorphoses* is *Philomela and Procne*. This 20 minute long part is probably the most written part of the whole 4.5 hours long piece.

The set for this part of the piece is rather small and made of dark burnt wood. Many accessories like guns, knives, doors, the lighting, make the scene look as realistic as in a horror movie. The sound part consists of a large monument of sound effects, music, stage events using 12 contact microphones hidden in the set and simple voice processing (mostly Psola and resonant filters). These elements make together a unique loud and violent environment within which actors have to fight against in order to find their place. The object created is an artificial world that oscillates between music abstraction and the apparent reality of the dramaturgy. We are here dealing with a piece that is so dynamic it is neither sound design nor a linear musical piece. The position of the piece is not truly at the service of the dramaturgy. It considered as an independent layer that will eventually be part of the final piece in its entirety.

Both sound effects and the music are tweaked in order to build one unique common texture that I eventually call music. There are indeed no sound effects so to speak because they are only suggestions for the actual narration and very close to the musical part. This moment, for instance, uses resonant filters with a different high cutoff frequency for each actor. All sounds have a harmonic function accordingly. This creates a melody constructed by all the elements; the music, the sounds, the actors and the set. These sound effects are also triggered on a time grid synchronized with the music. The choice for the right moment is decided by the sound manager: he has to decide within a second, which moment fits the best both with the music and stage events. Because durations and the playing of the actors varies, I found no better way than using a purely generative system. Nobody else than me and the sound manager know that all the rhythms and occurrence of resonant frequencies come from my Jtol tree structure library in Max (1.4.2). The direct link between the voices and frequencies of the resonators is nevertheless noticeable.⁸

The system consists of a Live session, a few Max4Live devices for voice effects and a Max patch running my system. This system runs is completely autonomous because I do not attend all performances. The sound manager uses my Max patch like a black box. It is an occasion for me to use an emergent system using moirés described earlier. This time, the jtol system uses nested loops with randomness.

⁸I used sigmund~ for such real-time analysis in a difficult noisy environment.

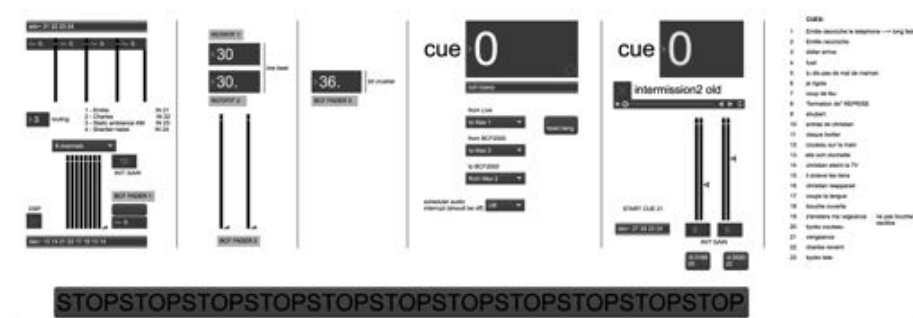


fig. 2.26 - Max patch for the first part of *Songes et Métamorphoses* (the *Songes* part). This runs in parallel of the Live session shown in figure fig. 2.24.

2.3.2 Fiction and randomness

My use of complex systems at the edge of human perception and the limits of understanding, randomness has become an important tool. Interconnections and synchronicity between systems are often more important than the random elements themselves. I often employ Perlin noise which provides an overall impression of a determined construction, a reality. Whether it is controlled or not, does not matter.

Authenticity perceived by the audience

A piece, seen as an inner journey, is based on the belief that there is something deterministic unfolding that can be discovered or understood as fictional elements. The piece exists through its material and immaterial content. But it also exists thanks to the medium, the context and the audience. The social aspect prevails and gives authenticity a real meaning (Buren, 1991). It is indeed another initial spark from which a piece spreads into reality (1.3.2).

“We can therefore very well deal with a work at once authentic and doubtful authenticity. We have there, connected, the authenticity, the real, the veracity and the vagueness, the vague, even the doubt. In the latter case the paradox can go as far as the authenticity of an inauthentic work. We already see that with the word authenticity we can use other words: veracity to begin, then sincerity and authenticity around which other words such as: indisputable, unmistakable, real, certain, true, sure, undeniable, exact, just, etc., will come in turn to try to identify what makes a work, a thought come under the authenticity or not. The authenticity of a work or author, for it to exist, must be recognized by others. It is the result of a judgment, a consensus. We can already see that the intrinsic authenticity of a work does not only depend on its own qualities but also on the

judgment that will welcome it.”

Daniel Buren, *De l'authenticité en art* (Buren, 1991).

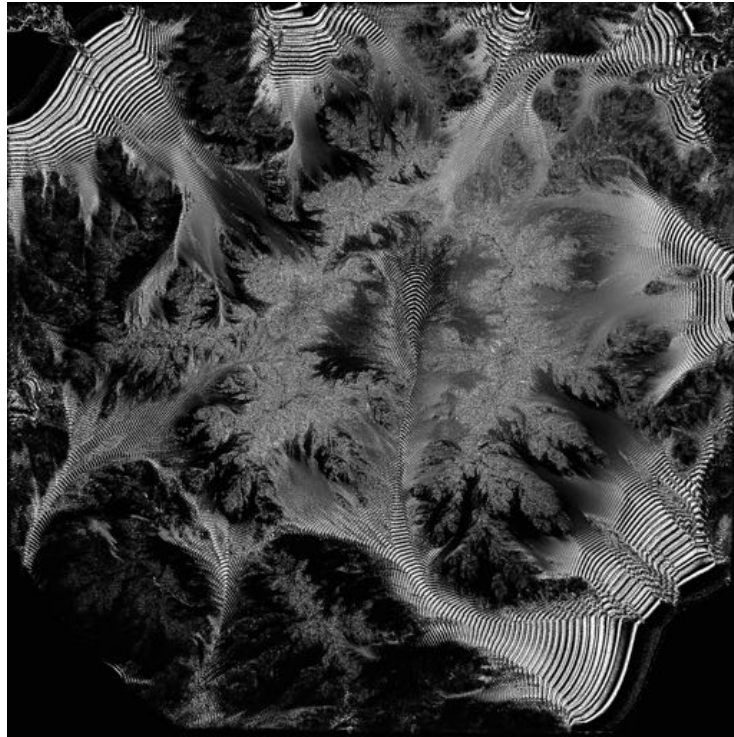


fig. 2.27 - *Kapteyn b* is a large high resolution print from 2015. A Julia set draws the plane with recursive curves. Its natural character is different from tiling (fig. 1.47). Its artificial quality does not come from dis-continuities but rather only from repetitions, pseudo-periodicity. After some tweaks to enhance deepness, a ray tracing technique was onto a special glass reflective and refractive material. The piece looks very much like a terrain heightmap from a real landscape excepted that it is a composed procedural terrain ^{9b}.

Existential question for coherence One involves veracity from coherence. The belief of accuracy is a obvious consequence and can provide the credibility people desire and expect. Getting the legitimacy of all automatic series of my generative pieces spring interesting questions about authorship and sustainability. Authenticity therefore questions the positioning of the creator and his work being recognized as “authentic”, true. This genuinely does not have to be scientifically accurate but is more a question of sincerity .

Existential questions of belief from others is not always enough and is sometimes not useful. There also needs to be feedback to the creator. Some people need to believe in their own work but this is not an obligation. I personally value

^{9b} Vue XStream is a software for easily generating and rendering artificial landscapes. For this kind of pieces, I personally ended using 3ds Max and Maxwell or V-Ray as a renderer.

the quality and the quantity of a work to exist. This means I have the tendency to think like a “worker” who gives value of the work itself. Even though my pieces are somehow conceptual, they are the outcome of experiments and the experience from previous works. This research is not something every composer is after. Some prefer to have, or not have, ideas and let others materialize them. This sometimes industrial way of working can create large pieces that one single person would not do. But they also miss the genuine coherent aspect of a piece. The boundary between both cases is totally blurred because no artist makes his piece totally from scratch: I do not code the system I am using. This is an question of organology: what is just a tool, or an assistant, and what is its position within the creative process. The consequence raises the question of the computational generative creative concepts that would do one part of assistant work while keeping a strong coherence in a piece.

Existential question for belief When working on a piece, I go through a whole process of personal discovery and experimentation. This is why I find the denomination “experimental music” often too restrictive. The process is slow, sometimes fastidious, but provides the necessary satisfaction for the piece to become a “piece.” Autonomous and self-reproduced pieces can generate a problem of authenticity. A problem that is similar for me to that of interpretation of music performed by instrumentalists. I need to believe in the created fiction during the elaboration and programming of the concept. The necessary experimental part happens before this. The following experiments become experienced and are left for the audience and myself afterwards, but perhaps have a lack of self-confidence, or radicalism. I sometimes revisit my decisions and the specific material the algorithm generated. In these cases, I feel have not objectively evaluated the program and I return to the initial processes. This back-and-forth work becomes part of the experiment and the compositional process. This is one reason why I use a supervised “black box” with machine learning in β *Pictoris f* (1.4.3). I intend to eventually add a feedback loop to the parametric process. Neural networks could learn from my supervision; my interpretation and reinterpretation. The next step will be the audience with interaction. I indeed still have difficulties with interaction from the audience or visitors in my own work. Probably because of my interest for old-style linear passive narration.

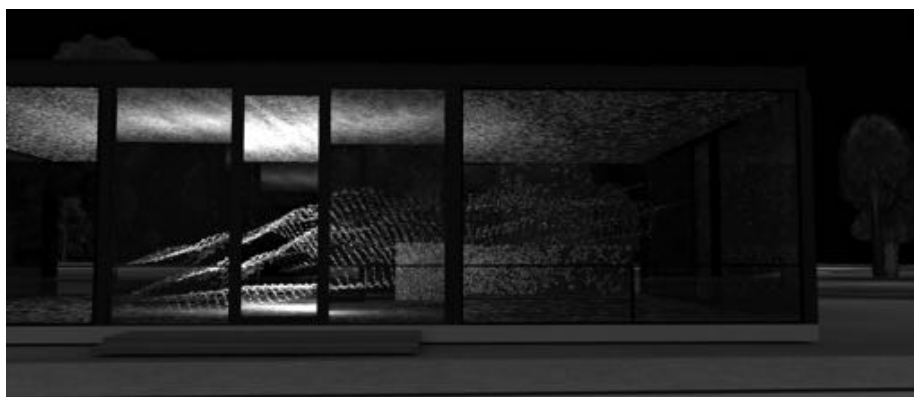


fig. 2.28 - Simulation of my performative installation at the *Greatbatch pavilion*. This piece is a following step from *Fomalhaut Γ* (fig. 1.23). The Greatbatch pavilion is part of Frank Lloyd Wright Martin House. The architect is Toshiko Mori.

Synthetic naturalist and emergent expressionist conceptions

Earlier I suggested that random processes could be interpreted as emergent coherent sources (1.4.1). I question whether the judgment and intuition, I use within my own feedback of compositional workflow could be replaced by randomness. Humans cannot themselves generate white noise, they are best with Brownian or fractal patterns. I use Perlin or Simplex noise generators as they are the best at closely producing natural and human gestures (1.4.3). Jackson Pollock's paintings explicitly raise this question of "human randomness". Roman Opalka's paintings explicitly raise this question of "human predictability".

The abstract expressionist painter leaves traces of his frenetic gestures onto large format canvas. He paints textures that would become a score when examined at a closer scale. This is a similar idea with *d/score/*. Fractal expressionists analysed Jackson Pollock's work to differentiate fractal works from machines and humans. Self-similarity is in the painting itself and also in the process. Jackson Pollock revisited pieces he had not adjusted in several weeks. Time with nature is part of the process, the fact that he waited to complete paintings demonstrates a sense of experimentation and feedback (2.3.2). Latency, a delay, was sometimes needed for the piece to eventually exist. On another time scale, works by David Tudor and Morton Subotnick also provide space for randomness, intuitive interpretation and control over real-time processes by using live synthesizers. The performance of these works often exists at the blurred boundary between determinism and live improvisation. The limits between predetermined automatism and, live intuitive and subconscious automatism.

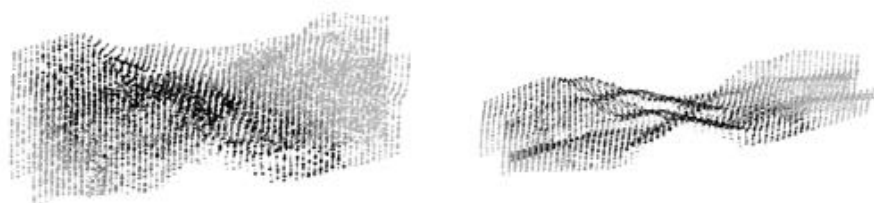


fig. 2.29 - Work for my performative installation at the *Greatbatch pavilion*. It will also use white lasers and a large set of speakers. The piece will consist of a human random composition of bright dots in the space.

Pierre Huyghe's aesthetic aquariums are great pieces. They are autonomous and very rich biospheres visitors can follow in an ecstatic mode: *generative biologic pieces*. It was ingenious to only add tiny artificial details on actual strange and rare fishes. The piece as a work of art can be questioned because it is only an aquarium. But this question quickly disappears with the mental state it provides to the audience and its clever composition rises.

“Three aquariums placed in the gallery contain biotopes transplanted from Monet’s ponds in Giverny, the geo-engineered site begun in 1893 and the subject matter of his Nymphéas paintings. The water lilies floating on the surface of Huyghe’s ponds can be viewed constantly. The sides of the aquariums are encased in switchable glass that conceals their contents, then randomly exposes the living organisms that lie under the surface of the painted subject. Unlike Huyghe’s previous aquariums, the focus of these pieces is the sunken man-made objects that have been modified over time by natural elements.”

In. Border. Deep exhibition, Hauser & Wirth gallerie, London, 2014.

Return, feedback into systems composition

Wandering Set is a series of pieces that are probably more “traditional” than the others presented in this text. They are indeed non generative linear pieces performed live by myself and were initially composed to experiment with the concepts described earlier (1). They also do not use the idea of emergence in the sense they have several discreet instruments. Each track is a Live instrument device such as *Operator* and *Wavetable* plus a set of side-chain compression and appropriate equalization.

These pieces consist of one unique generative system using two parallel and independent processes: first a parametric system with 2d Perlin noise: the random matrix generated is called *Jupiter* as in the Max patch shown in figure

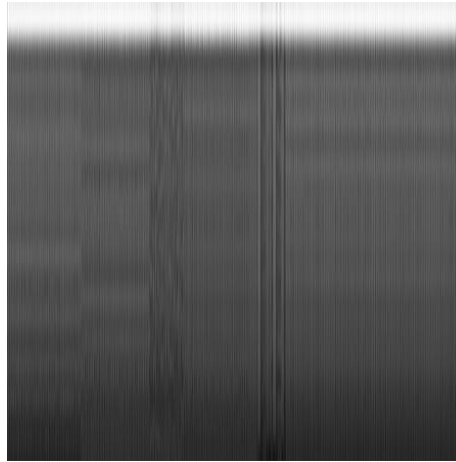


fig. 2.30 - *Wandering Set*'s rearranged artistic cepstrum. Mechanical repetitions can be seen in this short extract.

fig. 2.32. Then, a rhythmic nested loop machine using Jtol. The duration of the piece is fixed before the performance and its timing is *inflexible*.

The only composition choices I make before the performance are the complexity and the recursive aspect of the *Jupiter* matrix. I also have to choose the initial rhythmic phrase that will evolve during the performance. The only composition choices I have to do during the actual performance are the amount of repetitions together with a very important quantization ratio parameter. This latter is primary and offers the possibility to make the piece more or less complex.

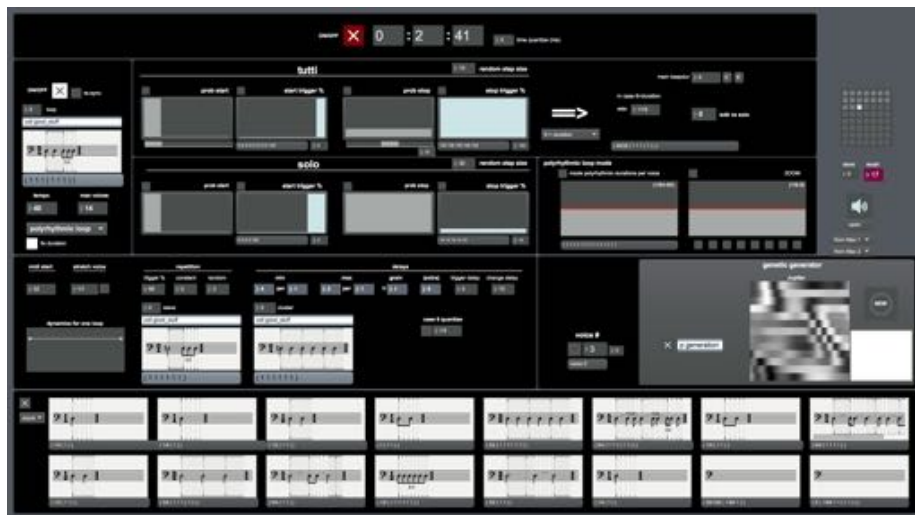


fig. 2.31 - Main performance interface used for the *Wandering Set* pieces.

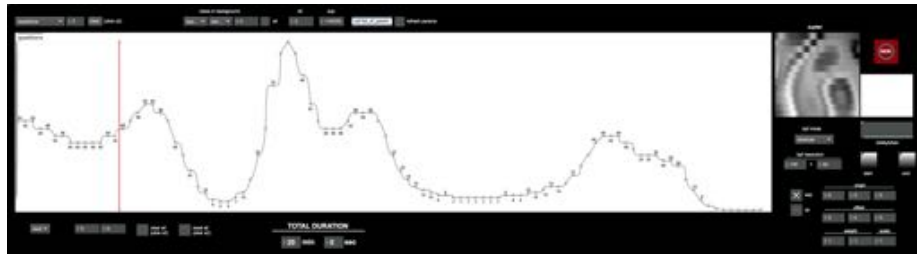


fig. 2.32 - Parametric part of the *Wandering Set* pieces using 2d Perlin noise. The curve on the left side is one line of the *Jupiter* matrix shown on the right. Each line of the matrix corresponds to one parameter. The initial noise matrix can be transformed using chebychef functions and various resampling functions in order to change the piece's resolution (amount of changes) at a macroscopic scale.

The performance act of these pieces then consists of choices that are made before and during the concert. It is interesting to notice that the composition is truly being done in all moments of the creative aspect including the performance. The amount of *improvisation* during the performance is as important as the randomness.

The audience does not know about the whole process and is supposed to only listen to complex repetitive layers. Its continuous characteristic comes from the way I chose to use the *Jupiter* matrix. People would maybe believe I am composing on the spot if they would not see I have no interface and I am only using the track-pad and a mini controller with faders. But in fact, what I perform does not matter to them. They only expect the act of performing; even if I was just playing a sound-file. These blurred borders between what is performed live and what is not does not affect the artistic quality at all in the social field I am playing in. I am enhancing this aspect by playing in total darkness for most of the cases and the particular case of *Wandering Set*.

2.3.3 Transition

We have seen the strong desire of a narrative which is not only connected with the time-line of my pieces. It is also connected with the concept itself and its subsequent context. Perceived complexity, coming from generative processes, creates a reality for the audience, which has initially no link with nature. This artificial nature is offered to the audience to be explored during the presentation or outside of it. It becomes interesting when linked with other people's realities. But the audience can even follow a random fiction when it believes in it. This personal universe is confronted with various realities. This exact encounter is the material point when and where the piece physically and socially exists.

2.4 Conclusion

We have seen that the system described earlier in this thesis only existed in conjunction with peripheral contexts. A sense of coherence provided by the generative mechanism is consequently denatured from its initial concept and early wishes. They are constraints needed for the piece to exist in various realities. These realities are personal, social and spatial. The fact that every factor can change accordingly raises the question of radicalism and authenticity for both my pieces and myself. Finding personal, social and technical positions is primary and indeed defines my art pieces within contexts, that are beyond purely methodological or musical, and feedback into the initial formal ideas. We can see therefore that the processes described earlier are, however, far from being a justification. Rather, they merge all together and shape a passionate mechanism, including a source of inspiration, necessary for that authenticity.

Conclusion

This thesis is part of a portfolio and describes the significance of the conceptual aspect of the pieces presented. Detailed inspirations and conceptions obviously and directly spring from my personal experience in various fields, such as contemporary classical music, dance, theater, opera, installations and so on. These conceptual and practical experiences hugely influenced the construction of a workflow and an identity, built up piece by piece over the past four years. This text starts with a rather conceptual section linking my past with instrumental music to my future with computer music. I raised the need for a score, which is different from the traditional paradigm for instrumentalists. Interpretation is linked here with exploration and consequently with the act of reading. I therefore offer people a subjective discovery of tiny patterns over time and space and within the concept itself. They offer a variety of perspectives of a one series of generative pieces. The aesthetic result is a minimalist controlled granular synthesis and is achieved using parametric and computational approaches for rhythms. My intention is not to create any generalization, but for each piece to be its own consistent object and for all of them to have an artistic connection. I mostly designed a generator of patterns using moirés emerging from infinitesimal scales related to the macroscopic forms. I made this emergence reproducible by applying the grammar of cellular automata to neural networks. This system can build a series of pieces that could later be autonomous and self-reproducible. This approach rapidly becomes too complex, thus too continuous, for myself and the listener. Surfing on the edge of chaos has become my composition technique.

On a less formalist perspective, we have seen that such sets of pieces lack significance until they are confronted with a spatial or social reality. As a composer, auditors and myself need to consider and believe in the work of art. Randomness at the genesis of creativity therefore becomes as deterministic as any other method. The constraints of reality and of collaboration with other artists materialize my work into what is socially considered as a piece. A sense of narrative is not only given by a real-time time-line and consistency within

it, it is also defined by what the work brings as a concept and as a piece itself. These fictional elements absorb external factors which are not initially intended to the parts of the piece. Here I presented examples of how I deal with tangible, space, timing and collaborators, which have become a part of my workflow. The repeated pursuit of integrating those social aspects within my concept is the adaptation and optimisation of my compositional system.

Machine learning, alongside randomness perception, allows feedback in the concept and thus brings it to life: mechanical automatism becomes a subconscious automatism and vice versa. As fascinating and autonomous as these compositions can be, my personality and culture nevertheless forced me to have some sort of control over it. This approach is rather new for me and I would like to believe it will eventually become fully automatic. This naive yet fascinating quest ignores the necessary satisfaction one needs for a work to become a piece. The main interest of a piece would be a given, unique transcendence that only a human can once provide to other humans.

Questions of ultimate control and preeminence are just consequences. To me, irrationality is imperative; it determines an art piece. I will nevertheless carry on searching, and researching, because it is my own reality. It may one day, after many iterations, truly work and become realizable into one sensible quest. Then it will be time to change it again.

Appendix

Presented pieces in the portfolio

The following list of pieces contains the most relevant ones for this thesis. I composed several other pieces over the period of the PhD.

Proxima Centauri

Premiered at Tokyo Art Fair December 2016 and Berlin Transmediale February 2017. This audio-visual piece is a generative piece and does not have any specific duration. The piece is for three speakers and three 4k screens. It uses several layers of interleaved and mixed cellular automata controlled by feedbacks and Perlin noise.

Joyeux Animaux de la Misère

Performed at Ircam in June 2014. This was the occasion for Pierre Guyotat to write a book and for Stanislas Nordey to read some extracts. This Ircam commission uses both an ambisonic and a WFS system.

Arealague

Presented for the Paris Fashion Show 2016. This piece uses the same methods than *Proxima Centauri* applied to electronic dance music culture with a more minimalist aesthetic.

Beta Pictoris

Premiered at the Moscou Digital Festival in 2015. This is a series of pieces using my formal workflow. They are all based on the same concept. They also all use envelope spatialization for 16 or 26 speakers.

Wandering Set

This series of piece are important pieces in my path because they are an experiment and early version of the tools and techniques described in this thesis. The fact I had a manual control on it shows yet another form of transformation of the initial concept and raises my surrealist automatic control.

Forma

Premiered at the Fondation Louis Vuitton in 2015. This piece is composed especially for the auditorium of the foundation where speakers are horizontally installed on the ceiling together with a stereo line-array. It uses a variety of syntheses controlled at macro and microscopic scales using the formalization described in the thesis.

The Nothing Seeking Answers: Invisible Stream

Premiered at Caffè Otto in London in July 2016. The piece was part of a collaboration with Elías Merino, Francisco Lopez, Daniel Del Río and Rian Treanor. It uses a version of my generative system where the sound quality emerges from deterministic trigonometric micro-canon structures. The piece has no duration but it has a beginning and end. It is perceptively interesting to listen to several series of two minutes in a row and compare them.

Les Quatre Temps Cardinaux

This 55-minute piece was premiered for June in Buffalo 2015 and also performed for the Boston Modern Orchestra Project. I did the electronics for this piece. It is possible to see how I implemented it with David Felder's instrumental music in the file *les_quatre_temps_422*. The video part makes intense use of moirés. Its aesthetic is inspired by nature. The file *les_quatre_temps_522* which is also a solo for the electronics shows this well.

Master Rock

Performed inside the Scottish Ben Cruachan dam within the mountain in October 2015. I was for commissioned by the BBC and Art Angel to write this piece for the 50th anniversary of the inauguration of the Ben Cruachan dam in Scotland. Master Rock literally tells the story of Irish workers who risked their lives building this underground cathedral. Recorded and performed inside a power station deep within the mountain, the piece is both a performance and a radiophonic piece. The text is from Maria Fusco.

Songes et Méthamorphoses

This 5 hours long theater piece was premiered at the Reims National theater in October 2016. It later toured for a year in national and regional theaters in France.

The piece is directed by Guillaume Vincent and was another Ircam commission for my part. It is a kaleidoscopic contemporary version of Ovid's Metamorphoses followed by William Shakespeare's A Midsummer Night's Dream. It is here interesting to see how I implemented "tonal pop singers" with a piano. It also shows how I added an oneiric sensibility to my formal syntheses. The piece presented *Songes_Part_23* is very important to me. The presented version is a stereo reduction of a multi-phonetic one. Its linear concept and length bring the listener into the same state as if it was drone music. Time disappeared completely. This piece uses 12 speakers around the audience and in the two stage sets. It normally starts and ends with the real voice of an actor. The sound is a physical model of a piano (ppiano~) and psola re-synthesis from an actor.

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